COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

January 1952

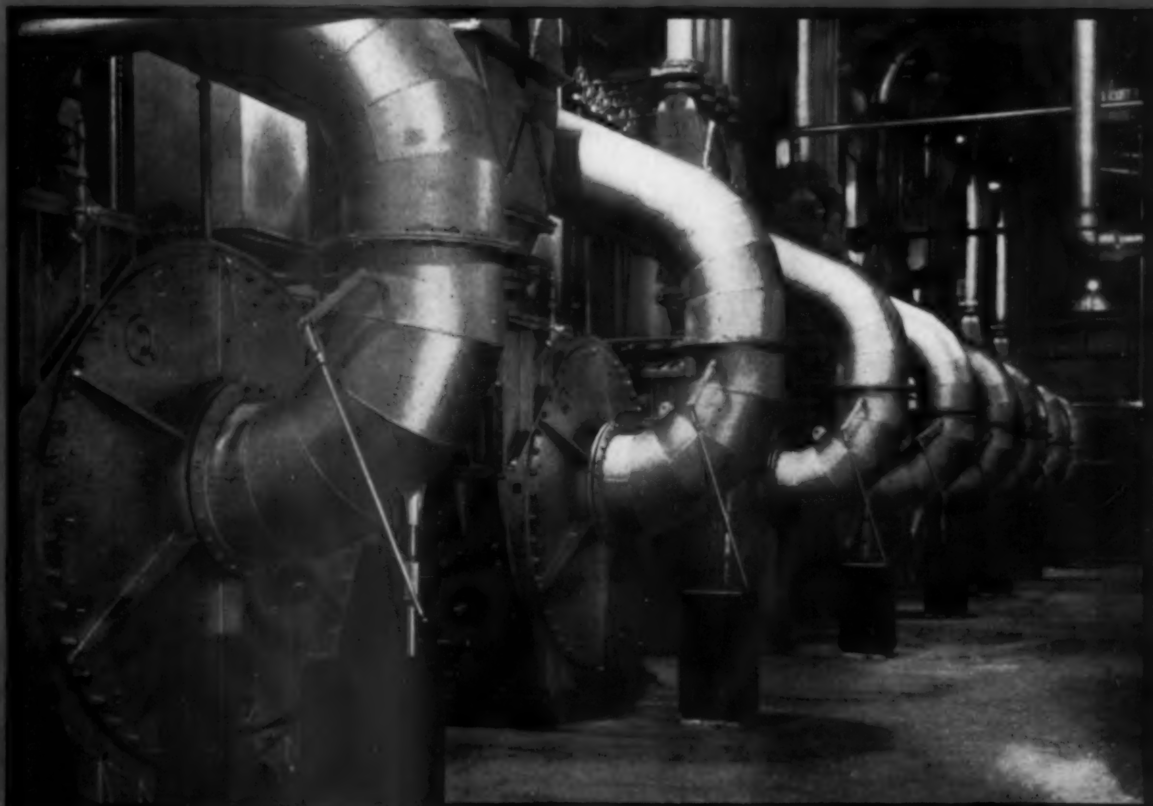

Photo by Willis Studio

Exhauster side of bowl mills at Lee Steam Station of Duke Power Company

Rehabilitation of Graphitized Welded Joints ▶

Reheat Boiler Operation and Design ▶

British Fuel and Power Projects ▶

COMBUSTION

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Feature Articles

Editorials

Departments

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COMBUSTION

Editorials

Metallic Sodium Finds New Uses

In connection with the future development of nuclear energy for the generation of power there have been a number of reports proposing that metals in the liquid state be used as a means of heat transfer. Now comes an announcement by the General Electric Company that, as a part of research carried out for a submarine intermediate reactor power plant, liquid sodium has proved to be a practical heat-transfer medium.

By comparison to water, sodium has the advantages of low pressure at high temperature and superior heat-transfer properties. Thus it is well adapted as a means of removing heat from a nuclear power reactor and transferring it to steam for driving a turbine.

But this is not all that has been accomplished with sodium in the liquid state. An electromagnetic pump has been developed and utilizes the metallic properties of liquid sodium in a manner similar in principle to the induction motor. One difference is that the electromagnetic forces are exerted on the sodium in a duct rather than on a conventional rotor. This type of pump is useful with radioactive fluids as it avoids possibility of leakage through seals and has no moving parts which may require service.

For many years metallic sodium was pretty much of a laboratory curiosity. To those who remember it primarily from demonstration lectures in elementary chemistry these new uses will seem even more of a wonder than its spectacular reactions with water.

Conference on Underground Coal Gasification

The United States Government will be host to the first International Conference on Underground Gasification of Coal on February 12–14, under the joint sponsorship of the Bureau of Mines and the Alabama Power Company. The three-day meeting will be held in Birmingham and Gorgas, Alabama, with sessions at the former place for the presentation of papers and discussion, and on-the-site inspections at the latter place where the third cooperative experiment on underground gasification of coal is now in progress. Taking part in the Conference will be a number of European scientists and experts in this field who are being brought over under the ECA Technical Assistance Program.

It will be recalled that the subject of underground coal gasification was first brought to the attention of American engineers some twenty years ago through reports in the technical press of experiments being conducted in Russia. Although that was before the days of the Iron Curtain, even then detailed information was lacking. In the interim, particularly since World War II, other experiments have been carried on in Belgium, France, French Morocco, Italy, the United Kingdom and the United States, and much information has been gained.

In general, the object has been to make use of coal which, because of thin seams or poor quality, would be uneconomical to mine. The reaction may be likened to that in a gas producer with the resulting gas becoming available for the production of synthetic liquid fuels or for the generation of power through the medium of steam or gas turbines. In fact, during the second experiment at Gorgas, gas from the burning coal operated two gas turbines for more than a hundred hours. Obviously, it is desirable to use this gas at or near its source.

Conditions differ somewhat in the several countries mentioned and a number of problems have been encountered, but an opportunity for the first-hand exchange of ideas and experiences, such as will be afforded by the forthcoming conference, should expedite the solution of such problems as remain.

Graphitization of Welded Joints

Much research and investigation has been directed toward the problem of graphitization since the failure of a welded joint at the Springdale Station of the West Penn Power Company in 1943. Elsewhere in this issue the program of The Detroit Edison Company to sample, examine and rehabilitate welded joints in high-temperature steam piping is described. Although the cost of rewelding and heat treatment is now probably in excess of $1000 per joint, this may be small by comparison to unscheduled crippling of generating capacity.

Graphitization continues to be a baffling problem in that it does not always occur in similar materials at the time predicted by taking into consideration length of service and temperatures of exposure. By taking preventive measures, the risk of failure due to graphitization may be greatly reduced. However, in the program described it is noted that the useful life of the welds and piping is sacrificed in the interest of safety. Thus many of the piping systems will have to be replaced at a date earlier than contemplated in their original design.

It is reassuring to know that The Detroit Edison Company has developed an effective program to detect signs of graphitization along with suitable corrective procedures.

Looking Back Over 1951

THE year just passed saw a vast expansion in production, covering both civilian and defense requirements which, according to the U. S. Department of Commerce, represented an increase of about 8 per cent over that of 1950. This was reflected in a greatly increased demand for electric energy which accounted for some 370 billion kilowatt-hours being generated by the electric power industry plus an estimated 60 billion produced by private industrial power plants for their own use. Over 73 per cent of that generated by central stations was produced by fuel, and the total output exceeded that of 1950 by about 13 per cent.

The peak utility demand reached nearly 70 million kilowatts whereas the total central station capability at the end of 1951 was around 78 million kilowatts, according to the Edison Electric Institute. Reserve margins were very small in some sections, notably the Pacific Northwest and some sections of the Southwest.

Approximately $7^1/_2$ million kilowatts of central station capacity were added during the year, which figure would have been greater had not lack of materials cut into scheduled deliveries. This applied not only to major units but to auxiliary equipment as well. Additions scheduled for 1952 exceed ten million kilowatts although, here again, the continuing materials situation is likely to necessitate further rescheduling with a consequent reduction in gross reserve margins well under the figure previously anticipated for 1952.

Steam capacity of more than 25 million kilowatts and hydro capacity of around $5^1/_2$ million kilowatts are now on order for delivery before the end of 1953, the largest percentage increase being in the South Central region of country.

In the industrial power plant field the greatest activity in the way of increased installed capacity is in basic lines such as steel, copper, aluminum, oil, etc., where there is a marked trend toward units of larger size. Over $1^1/_2$ million kilowatts capacity is said to be on order for such plants.

Defense Projects

To meet specific defense requirements for large blocks of power several projects were undertaken. Notable among these was the organization of Electric Energy, Inc., by five utility companies to build and operate a power station of 652,000 kw initial capability near Joppa, Ill. This will contain four reheat units operating at 1925 psi, 1055 F and supply half the power requirements of a huge atomic energy plant, the other half of which will be supplied with power by TVA. The latter now has 1,800,000 kw on order for installation in three new steam power stations besides having recently placed in service the first units of its new 750,000 kw Johnsonville steam plant.

A most unusual defense installation is that of Henry Kaiser's new aluminum plant in Louisiana containing eighty 1820-hp gas engines of the radial type running on natural gas.

Continual improvement was shown in the average net fuel consumption per kilowatt-hour of utility plants in the United States, the figure having decreased during the year from 1.19 to 1.13. The Schiller Station of the Public Service Company of New Hampshire, which employs a combination mercury-steam cycle reported 9133.7 Btu per net kwhr. The Dunkirk Station of the Niagara Mohawk Power Corporation reported monthly net station heat rates as low as 9440 Btu per kwhr.

Large Units Predominate

Realization that large units mean lower investment costs per kilowatt, as well as lower operating costs, is responsible for the adoption of a number of units of 150,000 and 200,000 kw in some of the new plants now under construction. Among those of the latter size now on order are two each for the new Kanawha and Muskingum Stations of the American Gas and Electric System, two for the new Colbert Station of TVA and one for the Cromby Station of the Philadelphia Electric Company. These are all initial installations in plants laid out for several units of such size.

The arrangement of one steam generating unit per turbine has become general practice in most of the new installations, as well as widespread adoption of the reheat cycle which has justified itself through increased thermal efficiency and simplicity of operation for units of 60,000 kw and over. This was borne out by a group of nine papers at the 1951 Annual ASME Meeting relating to reheat performance and experience, all of which were most favorable. In fact, one turbine manufacturer is authority for the statement that reheat accounted for nearly a third of the capacity shipped last year and will be employed in about two-thirds of the 3600-rpm turbine capacity to be shipped in 1952 and 1953.

Steam conditions for the very large units installed and ordered during 1951 range from 1670 to 2650 psi with 1000/1000 to 1100 F temperature, whereas at least a fifth of the total capacity installed last year was for pressures in excess of 1450 psi. The highest initial temperature of 1100 F will be employed for two 145,000-kw controlled-circulation units now under construction for the Kearny Station of the Public Service Electric and Gas Company of New Jersey.

New low-alloy ferritic steels containing chromium, molybdenum and vanadium have shown excellent strength at 1050 F and are being widely used for casings, piping and valves at this temperature in place of high-alloy stainless steels. Moreover, the ASME Special Research Committee on High-Temperature Steam Generation has undertaken a program to evaluate commercially available alloys as to their suitability for superheater and reheater tubing at metal temperatures up to 1350 F in anticipation of a further advance in steam temperature to 1200 F.

Controlled Circulation

One of the most significant events in the power field has been the placing of orders, during the last 15 months, for nineteen large high-pressure controlled-circulation steam generating units by nine well-known utilities. These range in steam output from 750,000 to 1,450,000

lb per hr and represent an aggregate capacity of 2,615,000 kw. The highest pressure is 2650 psi.

In the turbine field the trend in large units has been toward the tandem-compound 3600-rpm type, with single-shaft machines up to 200,000 kw on order. Several tandem-compound double-flow 3600-rpm units put out by one manufacturer incorporate a design that confines all the high-temperature steam to the same region of a single high-pressure casing.

The first tandem-compound triple-flow 3600-rpm reheat unit, of 121,000 kw capability and designed for 1800 psig, 1000/1000 F, was delivered during the year to the Waukegan Station of the Public Service Company of Northern Illinois. It has two high-pressure casings, one before and one after the point at which the steam is reheated. This manufacturer reports that thirty-five triple-flow reheat units are now on order.

Gas Turbines

Progress continued in the development of gas turbines for power generation as shown by two important orders placed during the year. One was for four 5000-kw units to be placed in service early in 1953 by the Connecticut Electric Light and Power Company for standby and peak-load service, and the other was a 15,000-kw unit to be installed in the Bartlesville area of the Public Service Company of Oklahoma. The last-mentioned unit is the largest of its type yet ordered for commercial operation in this country and is expected to be in service by 1953 or 1954.

Also, several 5000-hp gas turbines are reported as under construction for gas-line pumping and the Union Pacific Railroad placed an order for ten gas-turbine locomotives.

The Bituminous Coal Research Locomotive Development Committee, which for several years has been engaged in work on a pulverized-coal-burning gas turbine power plant for railway service, reported that the problem of pressurizing pulverized coal has been solved by employing a close-clearance rotary coal pump. However, although a new fly-ash separation system removes all dust larger than 325 mesh, there still remains the problem of removing all 10-micron particles from the turbine inlet gas so as to insure against turbine blade erosion.

Fuels

Bituminous Coal Institute reports an output of approximately 535 million tons in 1951, which exceeds that of 1950 by some 20 million tons. Of the total, domestic consumption of bituminous coal amounted to 465 million tons of which the electric utilities consumed in excess of 102 million tons. Exports to Britain and other western European countries reached a new high of 37 million tons, compared with one million in 1950, and required a large fleet of cargo ships to be taken out of reserve to provide the necessary transportation facilities. Exports to Canada amounted to 22 million tons.

Interest has been revived in the transportation of coal by pipe line, and an 8000-ft experimental line of $12^{3}/_{4}$ in. diameter near Cadiz, Ohio, is actually transporting up to nine thousand tons daily in the form of slurry. It is planned to extend this to 17,000 ft in the near future.

As to oil, the American Petroleum Institute issued a statement showing that in 1951 the petroleum industry in this country had met the greatest demand in history. Although the United States has approximately one-third of the world's oil resources, last year it accounted for 56 per cent of the total production of crude, which was a 4 per cent increase over the 1950 output. Our oil exports which had been declining in recent years, jumped to 156 million barrels and the domestic demand increased to 2,568,000,000 barrels, of which about $2^{1}/_{4}$ billion represented U. S. production. Daily operating capacity of U. S. refineries has reached 6.8 million barrels of which over 90 per cent is now being utilized. This new peak is attributable to several factors including increased use of petroleum products, the demands of our armed services, greater maritime consumption and interruptions in the output from Iranian oil fields. There was also a shift in oil from Central America to Europe.

However, during the year there was a significant swing, particularly along the Eastern Seaboard, from oil to coal as fuel for power boilers. This was influenced to some extent by stable conditions in the bituminous coal industry, unsettled conditions in the Middle East oil fields, increased oil prices and the anticipated increased defense demands for petroleum. In the Southwest oil and natural gas continued to predominate for boilers.

Lignite came in for increased attention and highlighted the program of the Fall Meeting of the ASME at Minneapolis with papers on its handling, storage and burning. At about this time the Robertson Lignite Laboratory of the U. S. Bureau of Mines at Grand Forks, N. Dak., was dedicated. It will be devoted to problems in the utilization of our vast lignite reserves in North Dakota, Montana and Texas.

Also, during the year the Bureau of Mines announced a new process, similar to low-temperature carbonization, for obtaining tar and various by-products from lignite, as well as a high heating value char suitable for boiler fuel. The process was developed at the Bureau's laboratory and pilot plant in cooperation with the Texas Power & Light Company and is soon to be applied by that company to generate power for a large new aluminum smelting plant in Texas.

Still another activity of the Bureau was the completion of an analytical study and tests of Colorado oil shale which indicated a probable yield of 30 gal of oil per ton of shale.

Successful suspension burning of bark refuse by means of high-set spreader stokers was announced and gives promise of wide adoption.

Atomic Power

Late in December the Atomic Energy Commission announced that small amounts of electric power had been produced successfully from heat energy released in the operation of the experimental breeder reacter recently completed at the National Reactor Testing Station in Idaho. In trial runs on two consecutive days more than 100 kw of electric energy was produced and used to operate the pumps and other building services. It was pointed out, however, that power generation is only incidental in this case, as the principal function of this reactor is the conversion of non-fissionable material.

(*Continued on page 42*)

Examination and Rehabilitation of Graphitized Welded Joints

By I. A. ROHRIG* and R. M. VAN DUZER†

A review of the practice of The Detroit Edison Company in systematically checking high-temperature piping welds for signs of graphitization and the corrective procedures employed to restore the welds.

SINCE the failure, in January 1943, of a welded joint in a high-pressure, high-temperature steam line at the Springdale Station of the West Penn Power Company (1)‡, a considerable amount of investigation of graphitization at welded joints has been carried on. Graphitization is a condition whereby carbon in the steel pipe changes to the form of free graphite as a result of long exposure at high temperatures. At least one more failure due to graphitization at a welded joint has been reported since the Springdale occurrence. Studies of the problem have been under the joint auspices of The Edison Electric Institute and The Association of Edison Illuminating Companies and also by individual power companies as well as by suppliers of high-temperature materials and equipment (2–14).

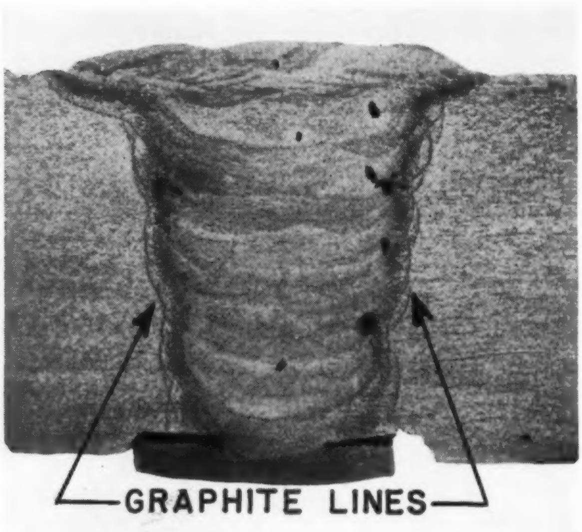

Fig. 1—Chain-type graphitization at a weld

In brief, graphitization has been found in carbon steels in use at 800 F and higher and in carbon-molybdenum steels in use at 900 F and higher. Although graphitization has been found principally in rolled pipe materials, several cases have been found also in cast valve materials and in forgings. Fig. 1 is an illustration of serious graphitization at both sides of a welded joint in carbon-molybdenum-steel, high-temperature-steam pipe material that had been in use at 900 F. The graphite forms the dark lines seen at each side of the weld. This sample illustrates the general location in which graphitization is usually found. Fig. 2 shows, in greater detail, the location of the graphite with respect to the weld.

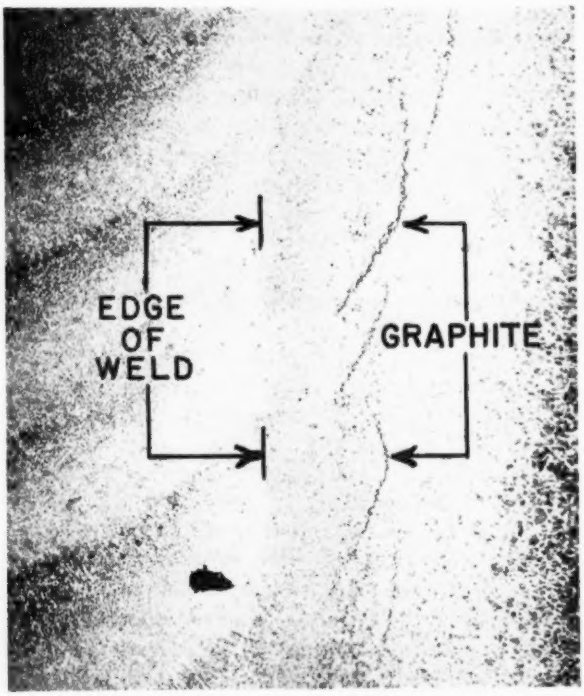

Fig. 2—Chain-type graphitization

The phenomenon of graphitization is peculiar in that it has not always been found at joints where it was expected to occur. In some cases it has been found to be of only minor consequence in power plants where the materials in use and service time and steam temperatures indicate that it might have occurred, or even be of a harmful type. Because of the potential trouble associated with the occurrence of graphitization at welded joints, many companies have sampled and examined welded joints to determine their conditions. This discussion outlines the methods used by The Detroit Edison Company for the sampling, examination, and rehabilitation of welded joints in high-temperature-steam piping.

Sampling of Welded Joints

The sampling of welded pipe joints is done during scheduled periods of outage of boilers and turbines. Certain joints are selected for sampling on the basis

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‡ Numbers refer to bibliography.

of information such as the following: (*a*) operating temperature; (*b*) length of service; (*c*) type of steel, that is, whether carbon or carbon-molybdenum and also whether high- or low-aluminum deoxidized; (*d*) type of material, that is, whether cast, forged, or wrought; and (*e*) prior thermal treatment of the materials and also of the joints when welded. Consideration is given also to previous information obtained for the same heats of steel or types of material.

The most practical method of removing samples from welded joints is by the use of the weld-prober which removes a boat-shaped sample. Fig. 3 shows the weld-prober attached to a steam line for removal of samples from a welded joint, and the type of sample removed is shown by Fig. 4.

Samples can be removed also by trepanning a core or plug out of welded joints. Such samples, however, are not practical for a bend test of the graphitized zone

Fig. 3—Weld-prober attached to a pipe line

of welds and may present some difficulty in closing the resulting hole, particularly if moisture is in the pipe or if steam is leaking through the line.

The weld-prober type of sample is preferred because it provides sufficient material for a bend test as well as for metallographic examination. A further advantage of this method of sampling is that the resulting cavity can be filled easily by arc welding. It is general practice to gage the depth of sampling to allow about $^1/_{16}$ in. of metal to remain at the bottom of the sample cavity to facilitate rewelding.

After sampling and welding of the sample cavity, some prefer to stress-relieve the entire joint as would be done for a newly made weld. Stress-relief of the sampled area can be done by peening and also by localized torch heating. It is the practice of this Company to do no stress-relieving immediately after sampling because the information obtained from the samples indicates the disposition to be made of the joint; that is, rewelding, heat-treatment, or no treatment.

Graphitization may vary in amount and also in its type of occurrence around the circumference of welded joints. Consequently, it is advisable to remove at least two, and preferably three, samples from each joint. If only two are removed, the samples should be taken 180 deg apart if possible, in order to obtain adequate information.

In the course of the examination of graphitized piping

Fig. 4—Weld-prober sample

several complete welded joints have been removed by taking a section of pipe out of steam lines. The pipe sections that were removed for test included carbon-molybdenum steel ASTM A-158 and ASTM A-206 that had been in service at 900 F, and carbon steel pipe, ASTM A-106 Grade B, that had been in service at 825 F.

Examination of the Samples

The weld-prober sample is cut into three pieces, for detailed examination, as shown in Fig. 5. The center piece, cut longitudinally from the middle of the sample, is a $^1/_8$-in. wide strip that is used for the bend test. The two remaining pieces are used for metallographic examination. The bend test coupled with visual or microscopic examination provides a satisfactory means of evaluating the condition of graphitized welded joints. The apparatus used by the Research Department of The Detroit Edison Company in performing the bend test consists of two dies mounted in a metallographic specimen-mount press as shown in Fig. 6. Pressure is applied by means of a manually operated hydraulic jack.

Photomacrographs of a bend-test strip both before and after the bend test are shown as Figs. 7 and 8. In this sample, serious cracking occurred at the left-hand

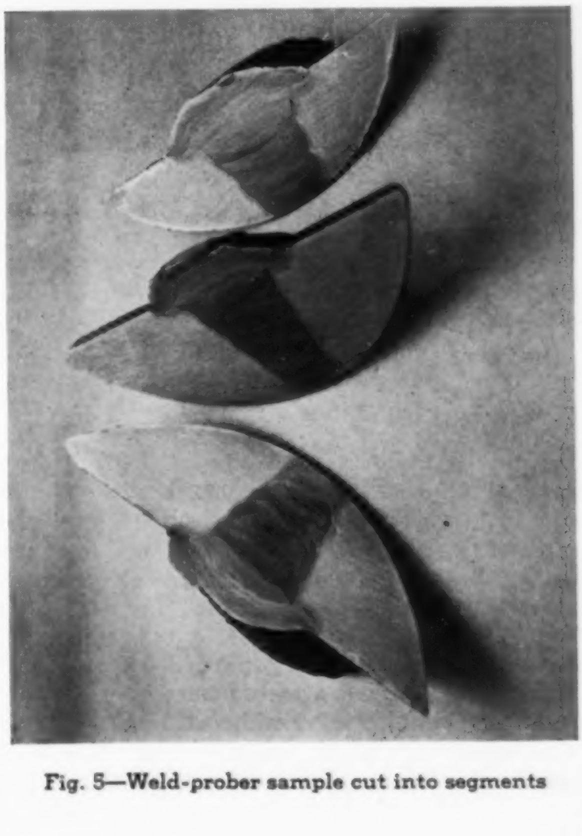


Fig. 5—Weld-prober sample cut into segments

side of the weld where severe graphitization was present, but no cracks occurred at the right-hand side where graphitization was slight.

The faces of the bend-test strips can be finished by filing, by grinding, or by means of a belt sander. Recommended thickness of the bend-test strip is $^1/_8$ in. (15). Etching before testing readily reveals the outline of the weld and facilitates the positioning of the specimens in the dies so that the bending can be made to occur in the graphitized zone. The sample should be observed carefully during bending so that a notation can be made of the angle of bend when the first crack becomes evident.

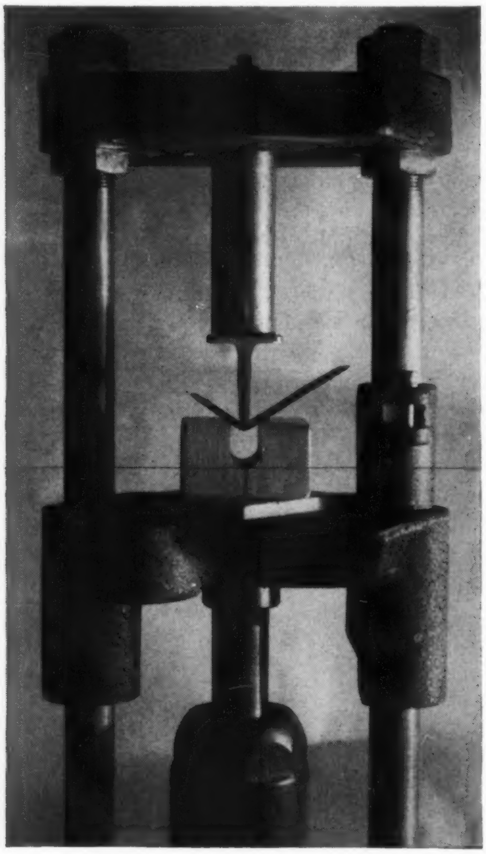


Fig. 6—Bend-test apparatus

The results obtained may be stated in such terms as length and width of cracks after bending, angle of bend, or elongation of the bent area.

Evaluating Graphitization

The EEI Subgroup on Graphitization of Installed Piping has suggested three classifications for describing graphitized conditions at welded joints, namely, "mild," "moderate," and "severe." Illustrations of each of these three types as well as bend-test strips from joints having the various types of graphitization are shown in the "Metallurgy and Piping Report," for 1951, of The Edison Electric Institute (14). A metallographic examination of the samples, combined with the results of a bend test, provides satisfactory information respecting the condition of graphitized joints. Although all occurrences of graphitization in high-temperature piping should be regarded as a sign of deterioration,

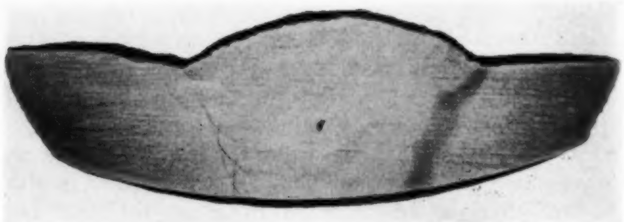


Fig. 7—Bend-test sample; etched

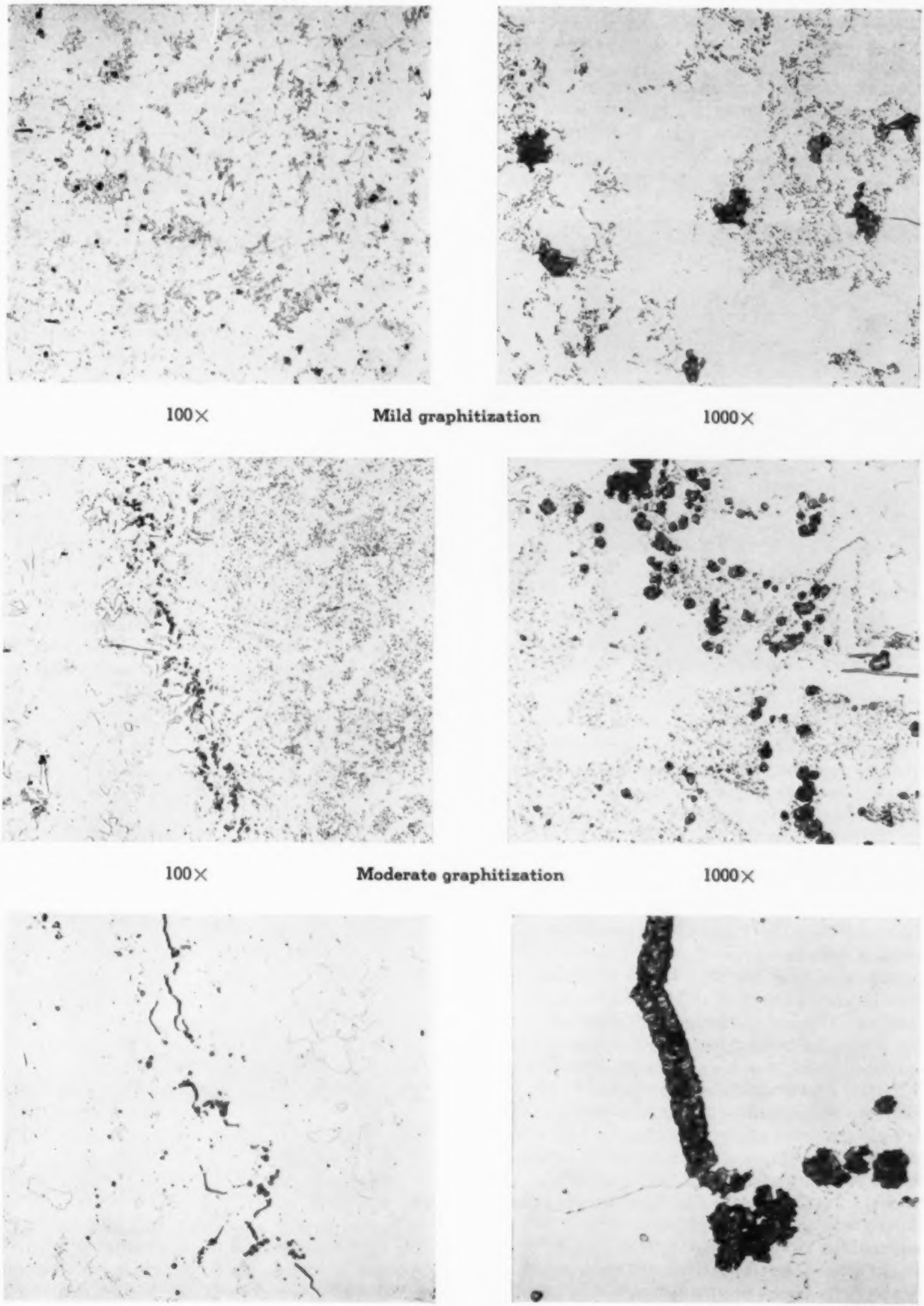
certain types of graphitization have a greater potentially harmful effect than other types.

Photomicrographs showing examples of three different types and degrees of graphitization, that is, "mild," "moderate," and "severe," are given in Fig. 9. A further description of the three types or degrees of graphitization is "general," "segregated," and "chain"-type graphitization. The examples shown in Fig. 9 are intended only as a guide; variations occur in the type and nodule size of the graphitization found in different heats of steel and also at different welded joints in the same material.

"Mild," or "general," graphitization is the least harmful and may have no appreciable effect on the service life of welded joints provided that the condition does not become progressively worse. "Moderate," or "segregated," graphitization, can be very harmful, depending upon the total amount of graphite present and the continuity and length of the graphite lines or paths. The results of the bend test should help to indicate what action is advisable when the graphitization found in the samples is classed as "moderate," or "segregated." "Severe" graphitization of the "chain" type is the most harmful of the three different classifications of graphitization and investigators agree that welded joints found to be thus affected should be rewelded without delay. Unless "severe" graphitization is found in the samples, interpretation of the results obtained from an examination and test is somewhat a matter of individual judgment. Each case, however, has to be considered individually and judgment has to be based on an adequate number of samples plus experience gained in examining samples containing graphite of varying degrees of intensity.

As a general guide, it might be said that if cracking occurs in the bend test in less than 45 deg, and chain or segregated graphitization is present, the piping should be rewelded without delay. If cracking occurs between 45 and 90 deg of bending and chain or segregated graphitization is found, plans should be made for rewelding as soon as circumstances permit. If no cracking occurs in the samples when the graphitized zone is bent 90 deg or more, no immediate action is necessary;

Fig. 8—Bend-test sample after bending



100× Mild graphitization 1000×

100× Moderate graphitization 1000×

100× Severe graphitization 1000×

Fig. 9—Different types of graphitization

although it would be advisable to sample again after an additional 25,000 hr of service to determine if a serious condition has developed. As mentioned previously, it is advisable to examine at least two samples from each joint.

In connection with examinations made of welded joints, Emerson and Morrow (5) have reported in detail on "slip-plane" graphitization found in carbon-molybdenum steam piping. "Slip-plane" graphitization is a condition of graphite segregation in lines that may

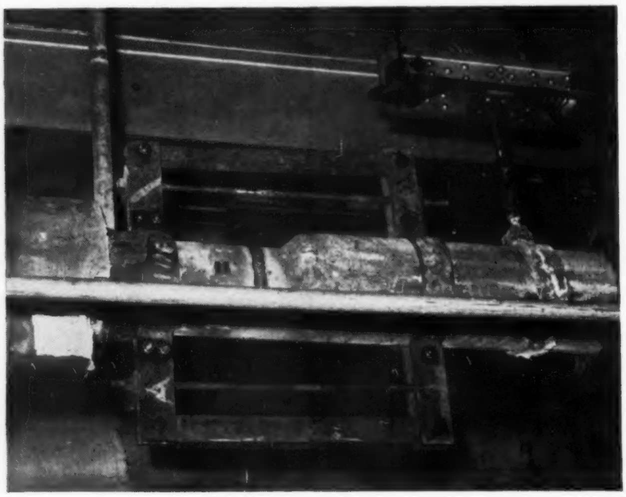


Fig. 10—Restraining yoke on a steam line during rewelding of a pipe joint

be outside of the weld-affected zone; however, it may reduce the ductility of pipe as harmfully as "severe" or "chain" graphitization. "Slip-plane" graphitization is believed to occur along planes where localized yielding or localized plastic deformation has occurred in pipe material. Reference No. 5 of the bibliography contains excellent illustrations of the "slip-plane" graphite.

Heat-Treatment of Graphitized Joints

In some cases, where graphite formation has not progressed too far, the harmful condition caused by graphitization can be removed or at least reduced by heat-treatment of the affected joints to dissolve the graphite. Heat-treatment of welded joints can be done by means of 60-cycle induction methods of heating while the joints are in position. This method of treating graphitized joints has been used with success since 1947 by The Detroit Edison Company. The heat-treatment consists of heating the welded joints to 1700–1725 F, followed by cooling at controlled rates. This treatment may be followed by a draw treatment at 1275 F, as recommended by Abele and White (12), to improve the ductility of the zone in which the graphite has dissolved.

Heat-treatment of graphitized joints should be employed only after a careful analysis of the condition of the joints as determined from an examination of a sufficient number of samples. The Detroit Edison Company has made extensive use of the 1700–1725 F heat-treatment of welded joints of both medium-carbon and carbon-molybdenum steel pipe as well as pipe-to-valve joints. The specific treatment used on graphitized joints in carbon-molybdenum steel and in medium-carbon steel piping, has consisted of heating to 1700–1725 F in approximately one hour, holding at 1700–1725 F for two hours, followed by controlled slow-cooling at 300 F per hour to 800 F. No draw treatment has been used on carbon-molybdenum steel following the 1700-F treatment. In several cases, the 1275-F draw treatment recommended by Abele and White has been used on seriously graphitized joints in medium-carbon steel to improve the ductility after the joints had received the 1700–1725 F treatment to dissolve the graphite. Heat-treatment of these several seriously graphitized joints was a temporary measure intended only to keep the joints in service until they could be rewelded during scheduled shut down periods.

The heat-treatment of graphitized joints to dissolve the graphite should not be viewed as a permanent cure in all cases (3, 12). The effectiveness of heat-treatment in restoring ductility to graphitized piping appears to be directly related to the extent of graphitization present before heat-treatment. Tests have shown that graphite, once dissolved, can precipitate again in the same place. However, tests have shown also that the 1700-F treatment appears to be the most effective means available for prevention of graphitization in both carbon and carbon-molybdenum steels. The treatment can be used at any time during the early stages of graphitization on joints that are in service. Smith and Miller (6) have proposed a postwelding treatment consisting of heating at 1300 F for four hours as a possible means of preventing localized graphitization. This treatment is very effective for carbon-molybdenum steel and has been used at a number of power plants.

Fig. 11—Induction coil on a welded joint

It is the practice of The Detroit Edison Company to brace pipe lines carefully before heat-treating in order to maintain proper alignment and pitch in the piping during heat-treatment of the individual joints. A yoke-type brace is used at the joints to prevent relaxation of the cold-spring, because if the piping is not fully restrained by bracing, cold-spring might cause stretching to occur due to creep in the heated zone. Fig. 10 shows the bracing and a yoke on a steam line. Fig. 11 shows an induction heating coil on a joint to be heat-treated. The bracing and the yoke are removed after heat-treatment.

Rewelding of Graphitized Joints

In cases of severe graphitization where immediate remedial steps are required, the welded joints and the adjacent graphitized zones can be removed by flame-gouging of the affected areas followed by rewelding, or, the joints can be cut out completely and a section of new pipe inserted. The latter method of repair requires two new welds whereas if the joint is gouged out, only one new joint is required. Fig. 12 shows a graphitized welded joint being removed by flame-gouging with an oxyacetylene torch. After flame-gouging, the scarf of the joints is finished by chipping and grinding before rewelding. A joint that has been flame-gouged and then ground preparatory to rewelding is shown by Fig. 13. Approximately $^1/_{16}$ in. of metal is left at the bottom of the gouged-out portion. The gouged area is made sufficiently wide to remove the graphitized zone at each side of the weld. This method of removing graphitized joints has been used by The Detroit Edison Company on medium-carbon steel pipe, carbon-molybdenum steel pipe, and carbon-molybdenum steel castings.

The joints are then rewelded using the same procedures employed in welding the joints originally. A preheat of 400–600 F is used on carbon-molybdenum steel; but no preheat is used on the medium-carbon steel. The new weld, in a joint that has been gouged out, is approximately 30 to 50 per cent wider than the original weld, depending upon the amount of metal removed.

Fig. 12—Flame-gouging of a welded joint

The Detroit Edison Company heat-treats rewelded joints in medium-carbon, and carbon-molybdenum steel piping at 1700–1725 F, followed by controlled cooling to 800 F. This reconstitutes the weld-heat-affected zones and thereby prevents or retards future graphitization at the rewelded joints. The treatment is the same as mentioned earlier for graphitized joints.

Program for Rewelding and Repacement of Graphitized Joints

An extensive program of sampling and examination of welded joints, as well as detailed physical tests of welds and pipe material, has been followed in plants of The Detroit Edison Company since the Springdale failure in 1943. In general, these tests have indicated that the pipe material outside of the weld zones was satisfactory for continued service and that the welds alone needed specific treatment.

Fig. 13—Pipe joint prepared for rewelding

As the result of that conclusion, the procedure adopted by this Company to cope with the problems of graphitization in high-temperature-steam lines has been as follows: (1) reweld and heat-treat at 1700 F all welded joints in high-aluminum ASTM A-158 carbon-molybdenum piping and in medium-carbon-steel piping ASTM A-106, Grade B; (2) replace with chromium-molybdenum steel, ASTM A-315 (1.0 Cr-0.50 Mo) all carbon-molybdenum and carbon steel welded assemblies that could not be rewelded in location, such as tee's, y's and manifolds; and (3) heat-treat at 1700 F all joints in low-aluminum ASTM A-206 carbon-molybdenum piping in which graphitization was in the early stage of development.

In the course of the program, more than 150 joints have been sampled, approximately 250 have been rewelded, and approximately 325 have been heat-treated. The replacement of tee's, y's and manifolds is being done during scheduled shutdowns of boilers and turbines so that it does not impair output. It is expected that this replacement program will extend over a period of four years. The program is now in its third year.

A chromium-molybdenum steel manifold that has been installed to replace a carbon-steel manifold in 825 F steam service is shown in Fig. 14. Induction coils for heat-treatment of three welded joints are seen on the manifold. Such welded assemblies can be replaced more readily than they can be rewelded.

An analysis of cost data obtained during the early part of the program indicated a cost of approximately

$920.00 per joint for rewelding and heat-treatment. This figure did not include the cost of replacement assemblies which were purchased from a fabricator. Where only heat-treatment has been required, the cost has been approximately $500.00 per joint. Costs now are proportionately higher.

In carrying out this program of selective rewelding, heat-treatment and replacement it has been realized that some of the useful life of welds and piping has been sacrificed in the interest of safety. The work is being done during scheduled outage periods, week-end shut-downs, and long holiday weekends. It is believed that the program has eliminated the possibility of

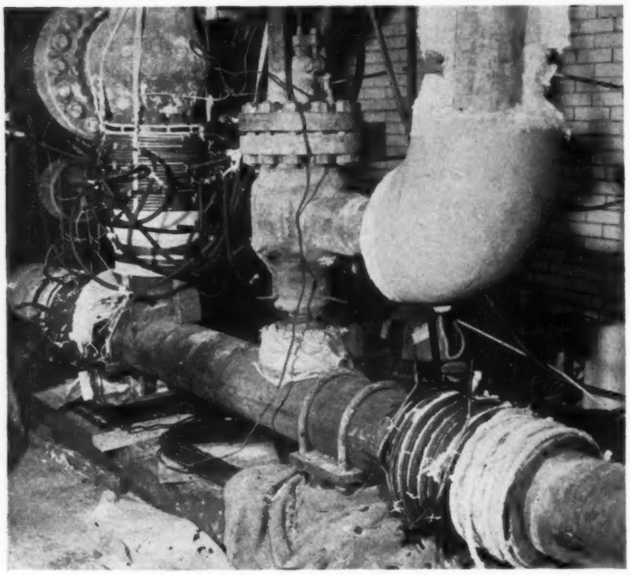


Fig. 14—Chromium-molybdenum steel replacement manifold

accidents and unscheduled crippling of generating capacity. Aside from the program outlined, annual sampling of selected welded joints will continue. It is present opinion that within the next ten years consideration will have to be given to replacement of the piping systems that now are being rehabilitated.

Acknowledgments

Acknowledgment is made to co-workers of the authors; specifically to H. A. Wagner, D. H. Corey, and Glenn Coley who assisted in formulating the graphitization program of The Detroit Edison Company; to E. R. Shiffrin who removed many of the samples; to C. A. Anderson who developed the induction-heating equipment used by The Detroit Edison Company for heat-treatment of welded pipe joints; to engineers of the Production Department who devised plant schedules for the work, and to engineers of the Construction Department who follow the field work.

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15. Discussion of Abele-White Paper (12), by H. J. Robar.

(*Continued from page 35*)

Earlier in the year announcement was made of an arrangement made by the Atomic Energy Commission with Monsanto Chemical Company, Union Electric Company of Missouri, The Detroit Edison Company, Dow Chemical Company, Commonwealth Edison Company, Public Service Company of Northern Illinois, Pacific Gas and Electric Company, and the Bechtel Corporation whereby representatives of these firms, organized into four working groups, will be afforded an opportunity to study the practicability of private industry building and operating reactors to produce plutonium for the Government and power for industry.

Other Developments

Among other events may be mentioned the employment of television in the furnace of a steam generating unit. First applied for this purpose at the Port Jefferson Station of the Long Island Lighting Company, it permits remote observation on the boiler control panel of conditions in the furnace at all times. Other applications of the "Utiliscope" that are finding widespread use are for stack and water-level observations.

More semi-outdoor power stations were put in service; and double furnaces were incorporated in designs of some of the very large units now under construction.

A new principle of generator cooling, termed "supercharging," made its appearance and has been applied in several installations. This involves forcing hydrogen at high velocity directly over the surfaces of the current-carrying conductors, thereby effecting a large material saving of copper and steel.

Also worth mentioning is the trend, in the central station field, toward use of miniature instruments. With panel space on control boards at a premium owing to the desire to have data available at more points in the steam cycle, these miniature instruments provide a logical development.

A Progress Report of Reheat Boiler Operation and Design

By W. J. VOGEL and E. M. POWELL
Combustion Engineering-Superheater, Inc.

Following is an abridgment of a paper presented at the 1951 ASME Annual Meeting discussing the performance of several reheat units recently installed. Some of the special features of operation and a series of tests conducted at the Dunkirk Station of Niagara Mohawk Power Company are described.

OF THE eighty-seven Combustion Engineering reheat units of postwar design thirteen had been placed in commercial operation by the end of 1951. All were put in service without any abnormal difficulties indicating that the addition of reheat equipment has not complicated the design or operation or reduced the reliability of the steam generating unit.

These units, with one exception, have been designed from certain basic principles and therefore are very nearly standardized. Fundamentally, the reheat steam temperature is controlled by vertical adjustment of the burners which are arranged for tangential firing. Since the primary superheater does not have the same temperature characteristic as the reheater, it is necessary to provide supplementary control which has usually taken the form of a spray-type desuperheater to limit the temperature of the high-pressure steam at reduced loads.

This control system was chosen instead of regulating the high-pressure steam with the burners to avoid the necessity of adding spray water to the reheat steam. Water added at that point would reduce the steam flow through the high-pressure turbine and sacrifice some overall cycle efficiency.

In order to appreciate the significance of these principles it is desirable to review briefly the heat transfer requirements of each of the superheaters involved. Saturated steam is supplied to the superheater at all loads. To maintain a constant steam temperature at the turbine throttle the heat added per pound of steam flow through the superheater must be held constant. As the load on the turbine varies the feedwater temperature will also vary, thereby changing the ratio of heat input to the unit and gas flow over the superheater per pound of steam generated. Therefore, to regulate the steam temperature rise in the superheater it is necessary to vary the entering gas temperature correspondingly. That temperature characteristic is indicated by the curve A on Fig. 1.

The problem in the reheater is quite different in that the temperature and pressure of the steam leaving the high-pressure turbine decreases with a reduction of load which increases the heat per pound of steam to be added in the reheater. The gas temperature leaving the furnace which will be required to satisfy the needs of the reheater is indicated as curve B. Obviously, no single furnace temperature characteristic can satisfy the needs of both superheaters. In order to minimize the quantity of water to be used for desuperheating and to obtain the maximum cycle efficiency over the widest possible load range, heating surfaces have been proportioned to require the same furnace temperature at full load. At reduced load the burners are regulated to follow curve B. This obviously, will exceed the needs of the superheater requiring the addition of spray water to limit the steam temperature. The quantity of water to be added

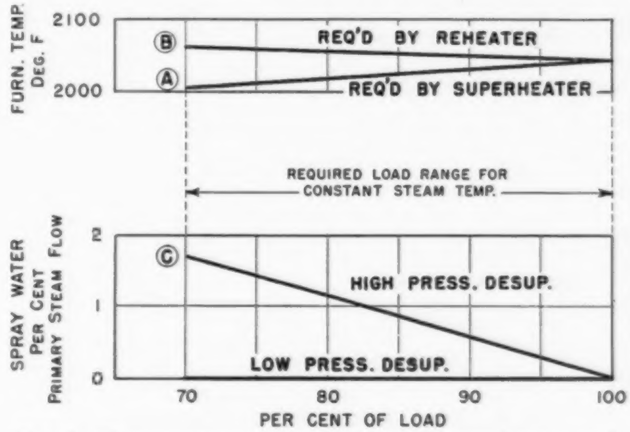


Fig. 1--Temperature characteristics of superheater and reheater

for this example is shown as curve C and reaches a maximum at the design point (70 per cent full load) equivalent to 1.7 per cent of the primary steam flow.

Dunkirk Tests

One of the first postwar reheat steam generating units was placed in service in October 1950 at the Dunkirk Steam Station of Niagara Mohawk Power Company. This unit serves an 80,000-kw G-E turbine having a maximum capability of 100,000 kw and supplies steam to the throttle at 1450 psig and 1000 F, reheated to 1000 F. Constant primary and reheat steam temperatures were guaranteed from full load to 70 per cent load.

Two series of tests were conducted on this unit during January 1951. The first series was run primarily to determine the performance characteristics of the turbine over a wide range of ratings. However, since each of

these tests was to be of 6 to 8 hr duration with constant steam conditions, an opportunity was presented to run gas temperature traverses to study the performance of each individual section of the superheater and reheater. The furnace was cleaned by normal operation of the soot blowers prior to most of the tests. The desuperheater valves were set in such a manner as to avoid the necessity for changing their position during the test. In this way furnace temperatures and steam temperatures were held constant by adjusting the burners alone. Pertinent data are summarized in Fig. 2.

The furnace outlet was traversed with thermocouples to obtain representative average gas temperatures leaving the furnace. These are plotted on curve *A*, and show the gas temperature required leaving the furnace to maintain constant primary and reheat steam temperatures. The steam temperature control range was considerably greater than guaranteed with full temperature of primary and reheat steam being maintained from full load to 36 per cent load. It will be noted that the gas temperature required to accomplish this is relatively constant over the entire range, dropping off somewhat at the minimum load because of a slight increase in excess air permitted by the automatic combustion control.

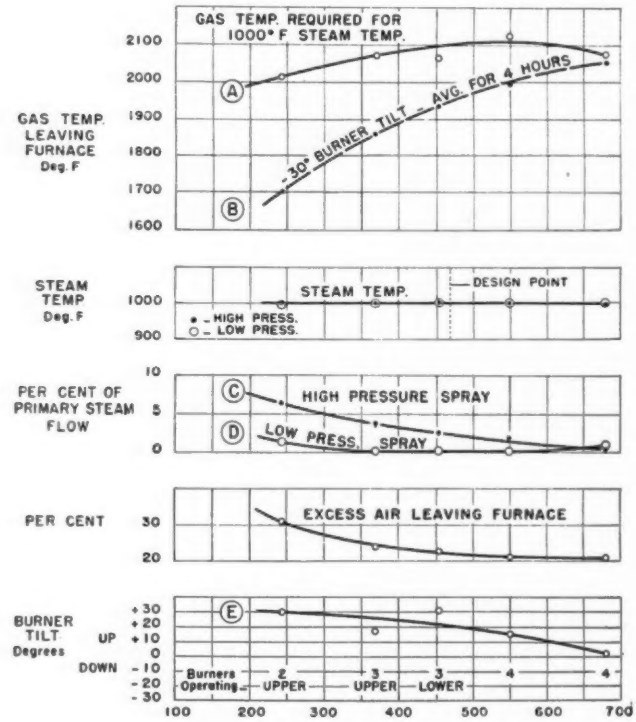


Fig. 2—Results of tests at Dunkirk Station

During the second phase of this test program furnace temperatures were measured while the burners were positioned at various degrees of tilt. Curve *B* has been plotted from these data to show the normal furnace temperature characteristic with stationary burners tilted downward 30 deg. This performance represents average conditions over a four-hour test period following wall blowing and illustrates the degree of control available on this unit for steam temperature regulation.

Curves *C* and *D* show the quantity of water delivered to the high- and low-pressure desuperheaters during the first series of tests plotted on curve *A*. It will be noted that there was an insignificant amount at full load indicating a perfect balance of heating surface between the primary superheater and reheater for the excess air corresponding to these tests. During normal operation a small percentage of desuperheating water may be used at times, depending on the frequency with which the furnace is cleaned and the degree of cleanliness.

The burner tilt at the start of each test is plotted on curve *E*. As the test progressed the burners were lowered to compensate for the ash accumulation on the walls. Four coal nozzles are provided in each corner of the furnace. The number and location of these in service during each test are indicated. The normal operating practice of taking the lower burners out of service as the load was reduced was of some assistance in maintaining high steam temperatures with a minimum change in excess air.

Russell Tests

Unit No. 2 at Russell Station of the Rochester Gas and Electric Corporation was placed in operation during November of 1950. This unit has a rated capability of 62,500 kw with the same steam conditions as Dunkirk and the arrangement is similar except for size and location of the air heater and fans. A set of charts showing steam flow and temperatures is presented in Fig. 3. It will be noted that a load of 475,000 lb. of steam per hour was carried for a substantial portion of the day which corresponds to 69,000 kw or about 10 per cent above the rated capability of the turbine.

During the early morning hours, the load was reduced to 9000 kw and at that time the steam temperatures were somewhat low (970 F primary and 825 F reheat). As the load was increased these temperatures rose and reached the design conditions at 27,000 kw or 39 per cent of full load at 6:30 a.m. Other load changes throughout the day were accomplished without any abnormal variations of primary steam or reheat temperature.

Performance at Hutchings Station

Two reheat units have been installed at the Hutchings Station of Dayton Power & Light Company which are substantially duplicates of Russell. The first of these was placed in operation in December 1950. After three months' operation, performance data were collected continuously at half-hour intervals for a two-day period to show the action of the burners and desuperheaters as affected by changes in load and furnace cleanliness. These data are shown on Fig. 4. This unit carried full load about 16 hr per day. During that time, the primary steam temperature was controlled by admitting from one to three per cent desuperheating water. The reheat steam temperature was controlled by burner tilt supplemented occasionally by desuperheating up to a maximum equivalent to one per cent of the primary steam flow, depending on the load carried and furnace cleanliness. Wall blowers were operated twice a day, once in the afternoon and again in the evening, at which time the burners would move upward and the low-pressure spray valves would close.

The load was reduced to 45 and 38 per cent for about three hours during the two nights reported. The design

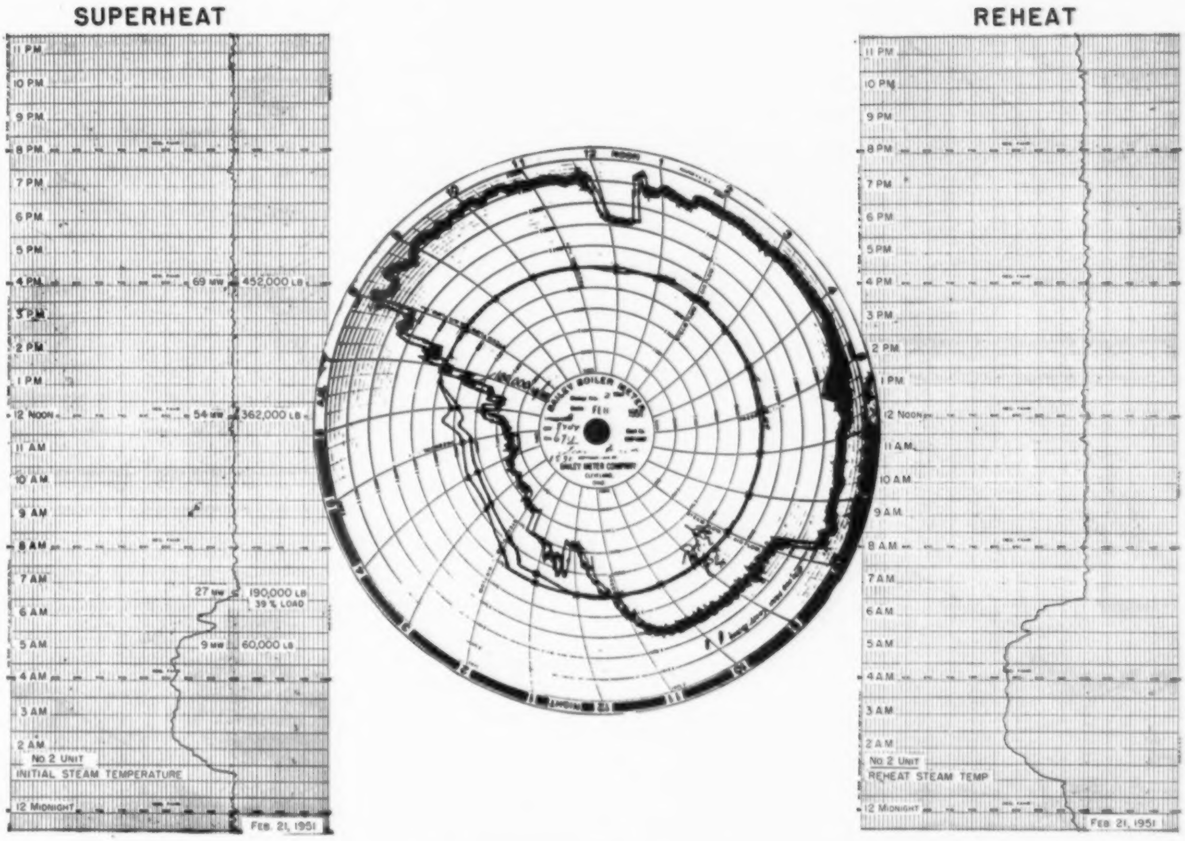


Fig. 3—Operating charts showing primary and reheat temperatures at Russell Station

temperature of the primary steam was maintained through both of these periods while the temperature of the reheat steam was reduced only 35 and 45 deg F respectively as shown in the curves below.

During the postwar period there has been a notable tendency toward greater conservatism in furnace sizing and the complete elimination of exposed refractory. This, coupled with the use of burner regulation for the control of gas temperature, has completely changed the nature of ash accumulations on the furnace walls as they were known in the past. This has permitted the development of wall blowers as a supplementary steam temperature control device. A number of plants have established the practice of operating one or two blowers at a time, spaced at intervals as required to regulate steam temperature. The particular blowers to be operated at any one time are determined by observation of the furnace and depend on the extent of ash accumulation. Such practice lessens the burden of the control equipment and will increase the equivalent capacity of the compressor and air-storage tanks with an air system. Although it would appear that this results in frequent blowing, actually it may correspond to less than one complete cycle per shift.

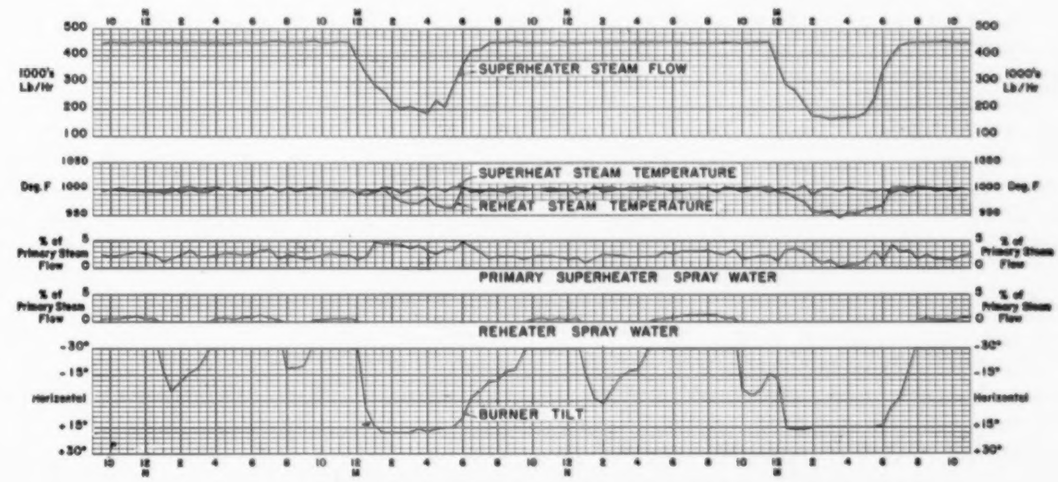


Fig. 4—Performance data from O. H. Hutchings Station

Reheater Protection

At one time many engineers expressed concern with possible complications to operating procedures resulting from the addition of reheat. One of the more important considerations was the protection of the reheater heating surface in the event of the sudden loss of electrical load at which time the steam flow to the reheater might be interrupted. In order to study this problem and establish standard operating procedures, the Niagara Mohawk Power Company arranged to conduct a series of tests on Unit No. 1 at Dunkirk. This program involved tripping the electrical load with the exception of station auxiliaries at three different loads from 25,000 to 100,000

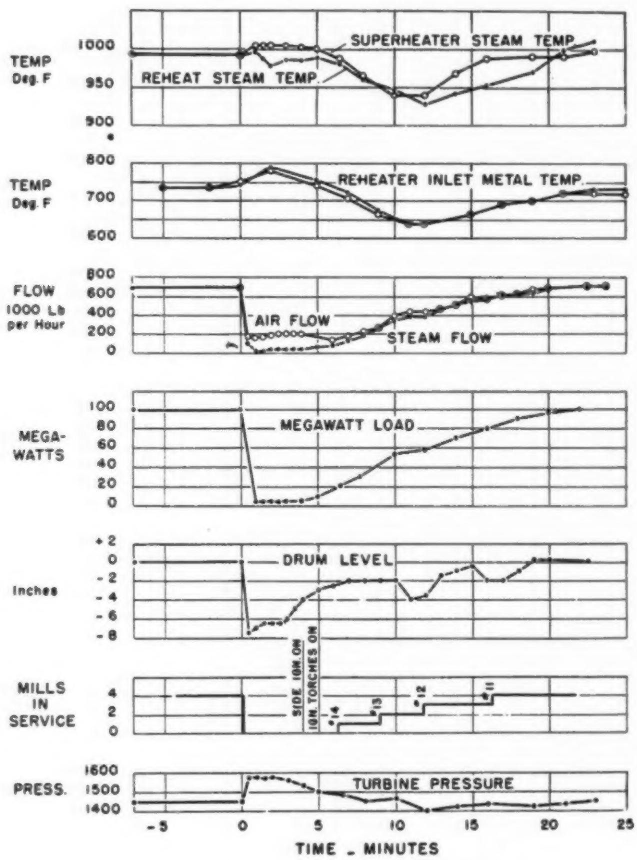


Fig. 5—Tripout tests at Dunkirk Station

kw. This unit is equipped with automatic relays to trip the firing equipment three seconds after the turbine control valve reaches a closed position.

Data pertaining to boiler performance for one of these tests are shown in Fig. 5. The load prior to trip out was 100,000 kw which was dropped to approximately 2,000 kw and following a short predetermined time delay restored to the original load. It will be noted that there was very little change in steam temperature until steam was taken from the boiler during the restoration of load. The maximum temperature change during this test was approximately 60 deg F. Thermocouples were installed on the reheater elements in the gas stream. During the period when no steam was flowing through the reheater, the temperature of these elements increased 40 or 50 deg F to a maximum of 790 F which was well within the limits of safe operation. The drop in water level in the boiler drum coincidental with the loss of fire in the furnace was only 7 in. This was restored to normal by automatic control equipment as the load on the boiler was restored with no abnormal fluctuations. The sequence in which the various burners were placed in service is indicated.

Low Load Operation

At the present time all of the modern reheat units operate at a high load factor. As more obsolete equipment is replaced and more efficient units develop, there will come a time when these present units must operate at much lower loads for considerable periods of time. Anticipating this, Niagara Mohawk specified that the units at Dunkirk be designed to be capable of operation for sustained periods at an evaporation rate of 50,000 lb of steam per hour. This was to be done with a minimum use of oil for the stabilizing pulverized coal burners. Side ignitors having a capacity of approximately five gallons of light oil per hour were installed on this unit for that purpose. Tests have been run at the low load specified to demonstrate the stability of that equipment. These tests were conducted with one mill in service with its corresponding set of side ignitors. Coal feed to the pulverizer was interrupted to simulate stoppages in the coal supply system and the fire was reignited from the ignitors. The load was also transferred from one mill to another in the same manner with no undue disturbance in the furnace. Furnace wall blowers were operated to demonstrate their effect on flame stability. These experiments were repeated many times with complete success covering an extended period of continuous low load operation of approximately 24 hr.

Conclusion

The combined operating experience from the many units already in operation covering numerous startups, tripouts and a variety of operating conditions has fully justified the faith so many engineers placed in the manufacturers' ability to design reheat units which would be at least as reliable as the standard straight through unit. The very substantial increase in cycle efficiency has been obtained with no sacrifice in the availability of the equipment.

British Power Expansion

In 1951 the British Electricity Authority planned to place in service generating capacity of 1100 megawatts, according to *Engineering* of Dec. 7, 1951. For 1952 the schedule calls for 1250 megawatts, although shortages of materials and defense needs may prevent the totals from being reached. Consumption of coal by British power stations in 1950 was 31,500,000 tons and was expected to rise to 38,000,000 in 1952 because of the general increase in electrical demand. However, because of the use of the more efficient stations now being commissioned, the increase in coal consumption will be less in proportion than the added electricity generated. Estimated fuel savings for the generating capacity scheduled for operation in 1951–52 will be about 500,000 tons.

Some Current British Fuel and Power Projects

The following notes are from the Thirty-eighth Thomas Hawksley Lecture, delivered by H. Roxbee Cox[1] before The Institution of Mechanical Engineers in London, November 16, 1951. In this the author reviewed research and development work now being carried on by the Ministry of Fuel and Power. These projects include the use of pulverized coal directly in a gas turbine, experiments with firedamp, coal gas and peat as auxiliary fuel, underground gasification of coal, heat-pump studies, and a pilot wind-power plant.

DEVELOPMENT of the gas turbine in Great Britain for aircraft and in Switzerland for industrial use pointed, at the end of the war, to the need for examining the possibilities of the industrial gas turbine against British background, that is, a study of its use with coal and indigenous fuels. The decision to do this filled a gap in the national research and development program when the work on liquid-fuel-fired gas turbines was well under way.

The coal-burning gas-turbine project of the Ministry of Fuel and Power has proceeded along the lines of developing large-scale laboratory combustion equipment, the running of an adapted experimental unit, and the design and construction of a unit for development purposes. The laboratory work has been done under the auspices of the Department of Scientific and Industrial Research at the Fuel Research Station in Greenwich, and at the British Coal Utilization Research Association at Leatherhead. At the former place two kinds of "dry" combustion chambers have been tested. One is a straight-through tubular chamber employing a multigrid burner and the other is a vortex chamber. At Leatherhead the "wet" combustion chamber is arranged so that combustion takes place largely along the walls where the ash remains in a molten state and is withdrawn in a fluid condition.

Parsons Experimental Work

The adapted experimental unit, previously mentioned, is a 500-hp open-cycle gas turbine belonging to C. A. Parsons & Company, and the coal-burning experiments with it have been carried on by that company under contract with the Ministry. The cycle arrangement is shown in Fig. 1 and the coal-burning combustion chamber in Fig. 2. This turbine is now operating successfully on coal, of which 80 per cent passes through a 200 mesh (95 per cent through 100 mesh and 99.5 through 60 mesh).

The design and construction of a 2000-kw coal-burning gas-turbine unit has been in the hands of the English Electric Company. This employs a cyclone slagging-

[1] Chief Scientist, Ministry of Fuel and Power.

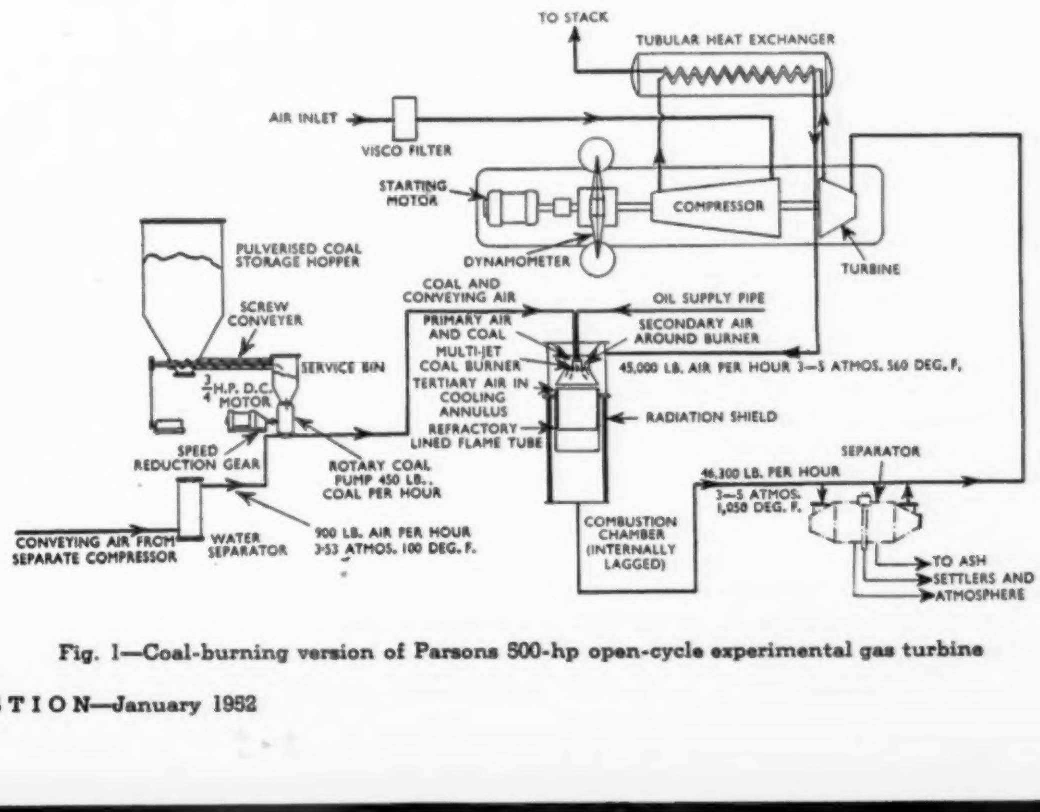


Fig. 1—Coal-burning version of Parsons 500-hp open-cycle experimental gas turbine

type of combustion chamber, as shown in Fig. 3, and the cycle diagram is represented in Fig. 4.

The aim has been to develop machines which do not need to discriminate as to the ash content of the coal. With the "dry" combustion chamber, such as employed with the Parsons unit, the problem is to clean the gases to such a degree that the remaining dust particles will not abrade the turbine blades. In this respect, opinion is divided as to the critical size, varying from 5 to 20 microns. With the slagging combustion chamber, as employed in the English Electric unit, while most of the ash is withdrawn in the molten state, some further cleaning of the gas is required.

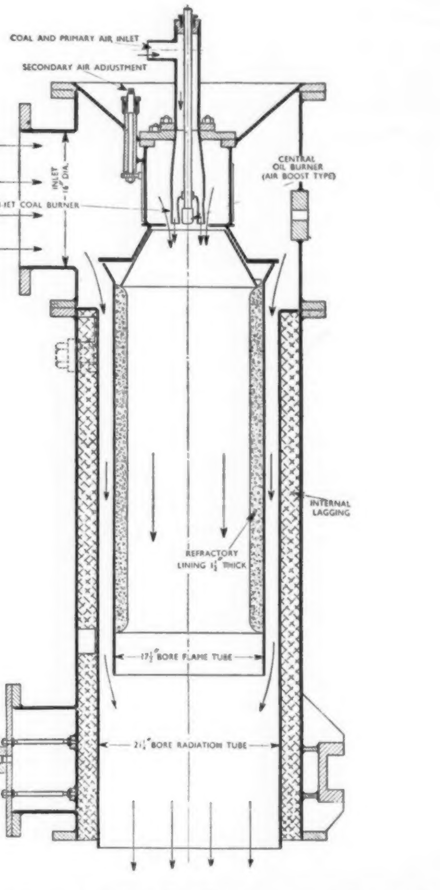


Fig. 2—Combustion chamber for Parsons experimental unit

By arranging the combustion chamber in two stages, in which the first produces combustible gas (a gas producer) and the second its combustion, cleaning may be confined mostly to the first, or gasification stage. This means that only about 10 per cent of the throughput has to be cleaned, compared with about 40 per cent with the single-stage slagging furnace and 100 per cent in the case of dry combustion. The cycle diagram for a 2000-kw unit with such an arrangement now being built by the Metropolitan Vickers Electrical Company for service in 1952 is shown in Fig. 5.

Another method of preventing ash from damaging the turbine blades is to prevent the products of combustion from passing through the turbine. Such an open cycle with external combustion is used by Parsons for locomotive application. Here the combustion air is preheated by the turbine exhaust and the products of combustion after passing through a cleaning chamber are led to a heat-exchanger and exhaust to the atmosphere. The working medium is compressed air. In fact the Ministry of Fuel and Power has ordered such a unit of 1600 hp from Parsons and the North British Locomotive Company for the Glasgow-London run. Its thermal efficiency is expected to be about 10 per cent at one-tenth load, 16 per cent at half load and 19 per cent at full load.

In the closed-cycle gas turbine, as in the externally fired open-cycle unit described, the products of combustion do not pass through the main turbine. In the closed-cycle turbines so far built this advantage is to some extent neutralized by the fact that the combustion products necessarily pass through the turbine used for supercharging the air heater. With air heaters operating at atmospheric pressure, however, any ash in the products of combustion cannot attack the rotating parts and any scouring effects are confined to the air heater tubing.

With this version of the closed-cycle turbine in mind the Ministry has ordered from John Brown & Company an atmospheric coal-burning air heater to be run with either the 500-hp experimental unit previously mentioned or with a 1000-hp turbine which that firm has in hand. The cycle arrangement is shown in Fig. 6.

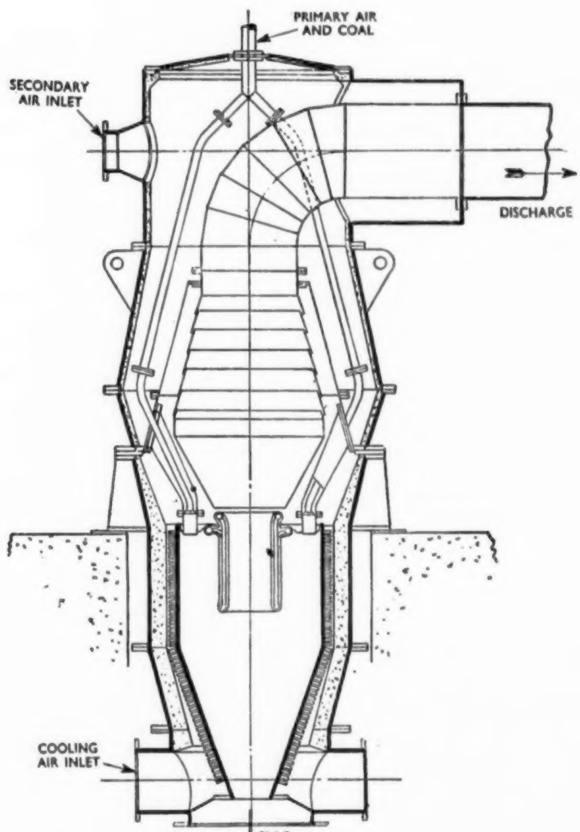


Fig. 3—Cyclone slagging combustion chamber for 2000-kw English Electric coal-burning gas-turbine set

In all these gas-turbine plants described, coal has to be injected into the combustion chamber and, except in the

locomotive unit, against a pressure of several atmospheres. Although lock hoppers have been tried for this purpose, the only satisfactory solution appears to be a good coal pump. Thus far, two promising designs of coal pump have been developed—one of the rotating-disk type and the other of the reciprocating-ram type. Successful preliminary runs have been made with both types employing pulverized coal against pressures from 3 to 6 atmospheres.

Use of Available Gases from Coal

Two familiar derivatives from coal or coal mining are also subjects of experiments. One is firedamp (methane) and the other coal gas. The former usually occurs in amounts of about 1 per cent or less in the ventilating air discharge from mines and, because of the difficulty of burning such a lean mixture, steps are being taken to investigate its use with an auxiliary fuel. An order has been placed by the Ministry with the English Electric Company

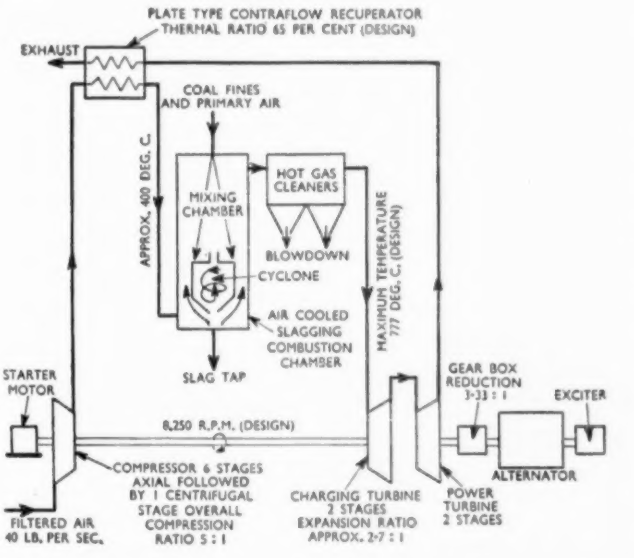


Fig. 4—Cycle diagram for 2000-kw English Electric unit

for such a unit in which part of the methane will be consumed in a temperature booster and the remainder as the combustion air for the auxiliary fuel, in this case oil or gas. This project is going ahead with the collaboration of the National Coal Board. It will be installed at a selected colliery and should be ready for operation toward the end of 1952.

Underground Gasification of Coal

The idea has been to try to make use of British coal which it would not pay to mine because of poor quality; also, unlike experiments in some other countries where the objective is gasification of that portion of a sloping seam lying above a horizontally mined gallery, attention is being paid to methods of creating underground systems that can be worked from the surface.

At a site near Chesterfield, vertical and horizontal surface drillings with their base in coal were made in 1949, and in July 1950 the coal was ignited by gas. Air was pumped down one vertical shaft in such quantity

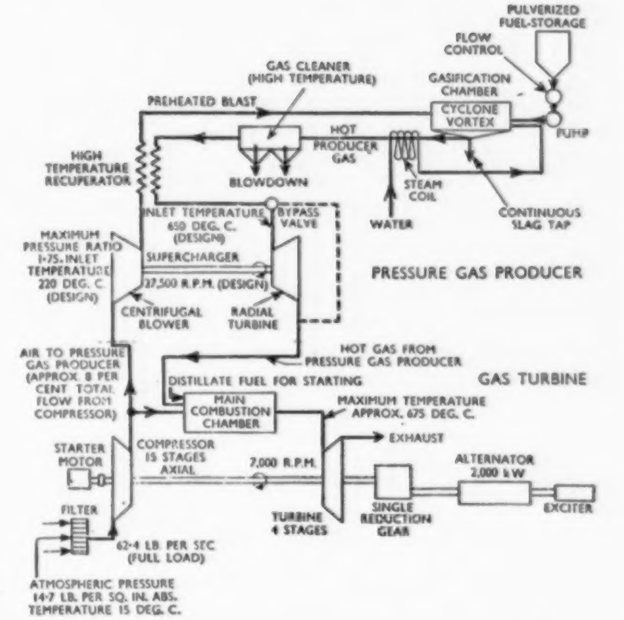


Fig. 5—Cycle diagram for gas-producer, gas-turbine set

as to maintain gasification reaction. The gas quality was maintained at an average of about 80 Btu per cu ft for the first ten weeks. However, as the burned-out space became greater, the tendency for some of the air to miss contact with the walls was reflected in a lowering of gas quality This quality was partly restored by introducing air at the side of the passage through an additional vertical shaft.

During the initial ten-week period over 100 tons of coal were gasified with a total thermal yield of about 67 per cent (49 per cent as combustible gas, 11 per cent as sensible heat and 7 per cent as steam).

The experiments so far have been confined to a study of the gasification process and the making of systems in flat seams. Utilization of the gas does not appear to present serious difficulty, but is being studied as a part of the economic survey. Until the end of 1950 the experiments were run entirely by the Ministry of Fuel and Power, with the advice of a scientific committee and the help of the National Coal Board, but during 1951 the latter has contributed with financial support, staff and facilities.

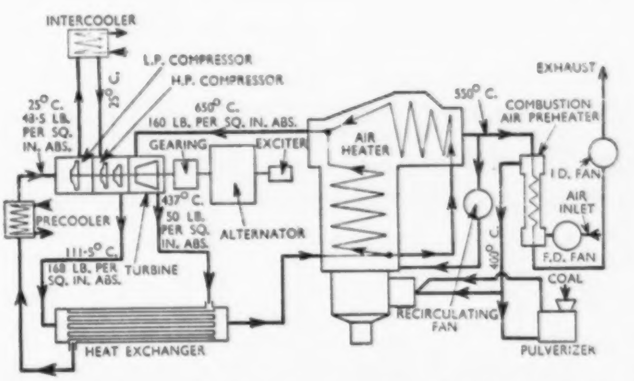


Fig. 6—Diagram of John Brown coal-fired closed-cycle gas-turbine plant with atmospheric air heater

Other studies by the Ministry of Fuel and Power have been directed at total gasification of coal by various processes, particularly by hydrogenation; also to peat utilization, the heat pump and to wind power.

There are two programs dealing with peat utilization, one under the Secretary of State for Scotland and the other under the Ministry of Fuel and Power. The former includes work on peat winning, as well as its use as gas turbine fuel, the basic scheme being to burn peat in an air heater which can be used with the 500-hp John Brown unit previously mentioned. The latter program involves an adaptation of the well-known Ruston & Hornsby engine to peat as fuel.

Wind Power Studies

In the field of wind power, investigations by the Ministry have dealt first with surveys of wind behavior over long periods and, secondly, contracts for pilot-scale wind-power generators of about 100 kw each. One of these is now just starting to operate at a site in the Orkneys and the other, which is being constructed for the British Electricity Authority, will have a special pneumatic transmission system for transferring power from the windmill shaft to the generator. Its blades will be hollow and their rotation will centrifuge air along their surface and draw it up the windmill tower which is in the form of a hollow tube. This air flow will drive a wind turbine connected to the generator at the bottom of the tower. Economic studies are also being made to determine the feasibility of this form of power.

The Power Plant Architect

By WALTER W. WEFFERLING

Chief Architect, Gibbs & Hill, Inc.

Increase in size of units, high labor and material costs, as well as advances in both mechanical and electrical practice, have left their marks on the architecture of modern power plants. How the various functional requirements are met, without sacrifice in architectural features, is here broadly discussed by the author.

ARCHITECTS who undertake the design of power plants are confronted with considerable differences in many respects from those customarily associated with the general practice of architecture, wherein the architect conceives and develops the project from start to finish.

The principal difference arises from the nature of the building and its basic conception as a coordinated architectural unit embodying the functional requirements of a power plant as developed by the mechanical and electrical engineers.

In the past, and to some extent even today, the engineering forces have been inclined to determine the general arrangements and physical space requirements without benefit of architectural advice or consideration. The engineering groups have come to realize, however, the essentiality of the architect as a consultant in the preparation of even the basic scheme, and most certainly in the development of the general arrangement or wherever space requirements and traffic flow problems exist.

Safety and Personnel Requirements

Modern high efficiency plant operation and personnel requirements make necessary the early consideration as to sufficiency and location of stairways, providing for good circulation and safety, the proper determination of platform locations, elevations and headroom to insure safe adequate access and working area, provision of hatchways and elevators to serve the coordinating needs of a plant.

The personnel requirements of modern plant operation are such that the utmost thought must be given to the efficient arrangement, comfort and livability of the general layout; good lighting and ventilation are essential. Proper lighting, air conditioning, ventilation and space provisions are highly important also in planning of the control room, office spaces, laboratory, machine shops, locker, shower and toilet rooms. The engineers have come to depend upon the architect to provide these many features within the structure required to house the mechanical factory. It has, therefore, become most essential that the mechanical, electrical and structural engineers work together with the architect as a team in close cooperation to assure the ultimate development of each problem.

The location on the site, usually determined by engineering considerations such as availability of water, railroad sidings, zoning restrictions or prevailing winds, should be studied by the architect in collaboration with the engineers. It is his job to plan the main approaches, secondary roadways, parking and recreation areas and landscaping.

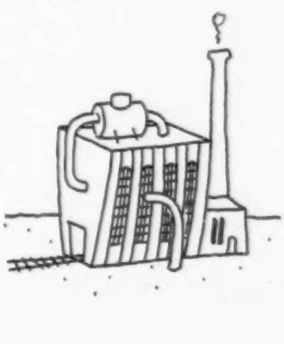
Color Schemes Important

In the early planning and purchasing of equipment, too little thought is given by the engineers to any overall color harmony for various equipment delivered to the job "factory finished," also to the proper type of base or priming paint for equipment to be finished at the job by the painting contractor.

An important part of the architectural design is the painting and color scheme of the finished plant—this is essentially the architect's province and he should be consulted on the color selections of all factory-finished equipment items, especially such as boiler and turbine boards and electrical control and relay boards which invariably are located in the same room or area, in order to assure a harmonious blending into the finished color scheme.

A few decades ago the architect was occasionally consulted by the engineers, but merely to design a façade for the structure. No longer, however, are façades designed as replicas of some feudal bastions. Instead, the utilities have joined the industries in the design of their modern plants, with the expectation of good clean architecture, stressing the functional housing of the generating equipment within modern structures.

The varied heights, the size and the massive areas of the modern plants, whether enclosed or semi-enclosed, offer many possibilities for the architect. Some are kept very simple, with clean lines and by a careful selection of materials, while others are more elaborate, with featured entrances and landscaping and by the use of more costly materials. Whatever the problem, there is nothing inherent in it that a good architect cannot master—the design is his. The materials, simplicity or boldness and special features are usually dictated by the economical approach or by the wishes of the client. It is therefore impractical to express any preference here for any particular materials or construction methods as each project offers a new problem for the architect.



Facts and Figures

About 75 per cent of the bituminous coal mined in the United States is machine-loaded.

•

Silica carryover is not susceptible to mechanical separation.

•

Approximately 20,000 kw of electricity is required to produce one ton of aluminum.

•

Distillate oils represent those petroleum fractions that boil off at between 350 and 750 F.

•

The maximum transmission voltage employed commercially thus far in this country is 330 kv.

•

Increased steam pressure and temperature decrease the solubility of calcium and magnesium salts in the boiler water.

•

One basic cause of smoke is the cracking of hydrocarbon vapors released from the heating of coal.

•

With the coal situation in England becoming acute, jobless Italians are reported as being recruited to help out the manpower shortage in British coal mines.

•

According to the American Petroleum Institute, the oil industry in this country last year spent over 200 million dollars in exploration for new oil sources.

•

With large units employment of reheat reduces the calculated turbine heat rate, in Btu per kilowatt-hour, from 4 to 5 per cent, depending on the steam conditions.

•

Gordon Dean, chairman of the Atomic Energy Commission, is authority for the statement that the Commission's current construction and operating programs are consuming stainless-steel tubing at a rate equal to about one-half the total national production.

•

Some of the oil refineries on the West Coast are reported as extracting hydrogen sulfide from their refinery gas and, not only burning the cleaned gas, but deriving a substantial revenue from the sulfur that is extracted.

•

Government statistics indicate that there are close to 3900 electric utility plants in the United States, 60 per cent of which are privately owned. Steam, although representing only about 27 per cent of the total number, accounts for some 70 per cent of the total electric output.

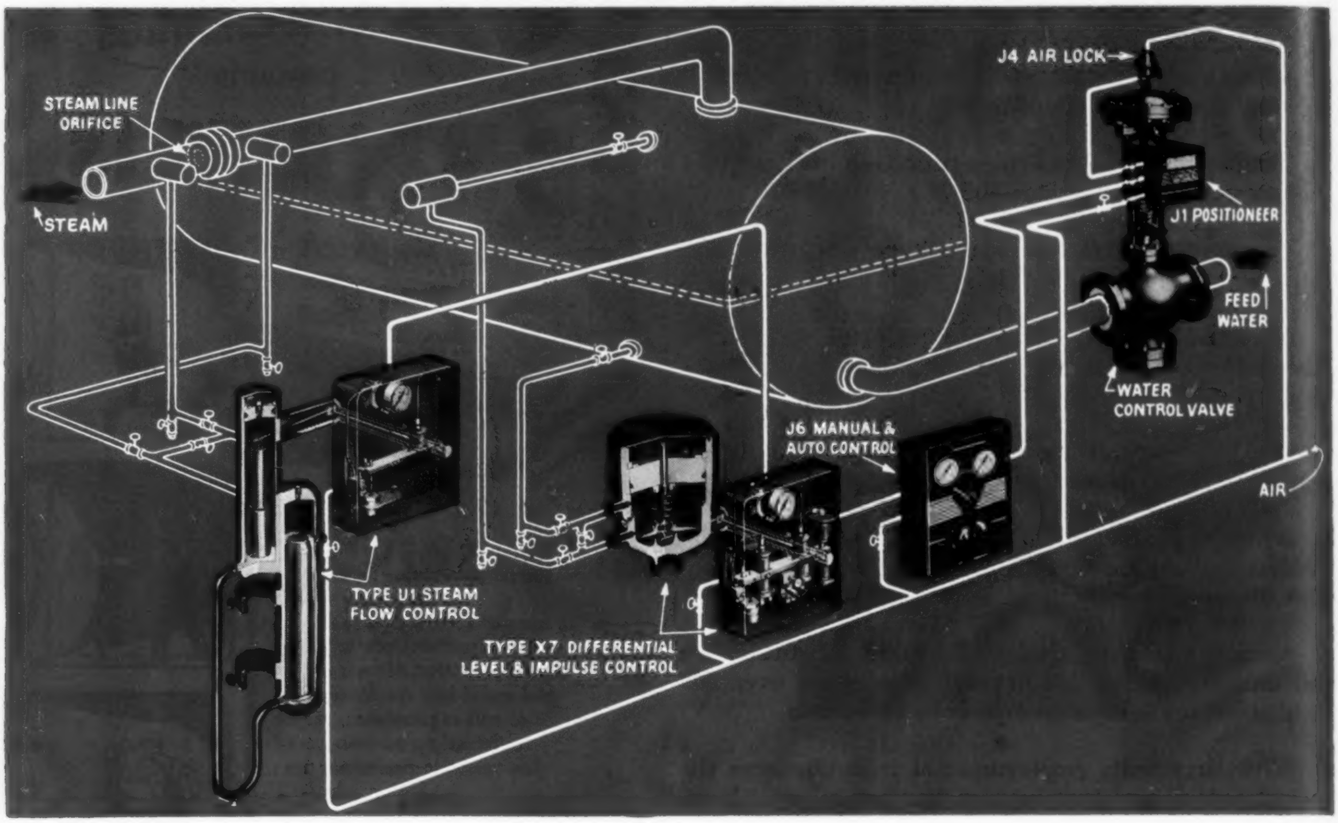
•

Preliminary estimates for the year just passed indicate that electric utilities, as a group, are now the largest consumers of bituminous coal, having slightly passed the consumption by by-product coke ovens. This is subject to final checking when all reports become available.

•

Only about 10 per cent of the manganese used by the American steel industry is supplied by domestic producers, the remainder coming from India, the Gold Coast, South Africa and Brazil, with small amounts from Mexico, Chile and the Philippines. Imports from Russia, the world's largest producer, have practically ceased.

Swartwout Impulse Regulation assures correct feed water supply under any load condition



SWARTWOUT two-element controls—by utilizing the very forces that cause false drum level—produce a corrective impulse that assures correct level even under rapid load swings. Since "shrink" and "swell" are functions of *rate of change,* as well as magnitude of load, only Impulse Regulation gives satisfactory operation under *any rate of change in load of any magnitude.*

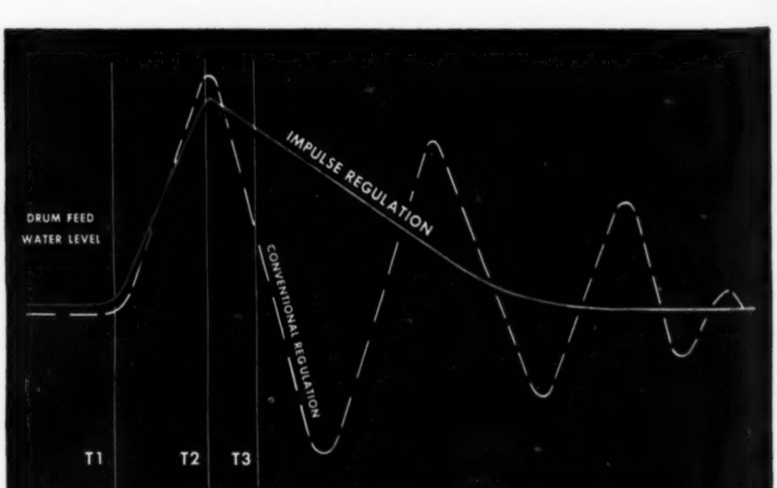
Type U1 flow transmitter takes square root of steam line orifice differential and feeds airloading pressure, which is directly proportional to steam flow at all flows, to X7 differential level and impulse control. X7 unit positions flow valve by sending airloading pressure which is result of combining *rate of change* of steam flow function with water level.

Graph *(right)* shows how proper combination of these forces, plus reset and setback features, assures that valve will give desired operation under *any* load condition. System can be adjusted to maintain drum level constant at all loads, carry it high at high loads, low at low loads, or vice versa. In addition to this FW6 two-element system, Swartwout also makes an FW7 three-element impulse regulating system. Other types include FW5 single-element system and SC (FW1) thermo-hydraulic system.

A-3753

Swartwout

POWER PLANT EQUIPMENT



SEND FOR BULLETINS S-27, S-20-E • THE SWARTWOUT COMPANY, 18511 EUCLID AVENUE, CLEVELAND 12, OHIO

Incineration of Wood Waste

The office of the Los Angeles County Air Pollution Control District has sent in copy of a paper by R. L. Chass, its assistant director, and E. E. Feldman, executive secretary of the Furniture Manufacturers' Association, dealing with "Incineration of Wood Waste in the Los Angeles Area." This paper, which appears in the Journal of the Forest Products Research Society, devotes considerable space to conditions peculiar to and regulations in Los Angeles County where so far there appears to have been little justification for utilizing wood waste as fuel because of the abundance of low-cost oil; hence incineration has become a popular means of disposal. This, of course, is contrary to practice in many other sections where wood waste is burned to produce steam. Space here does not permit reviewing the many local aspects, but the paper contains certain basic observations and operating suggestions on incineration of wood waste which apply to incineration in general; hence these points will be reviewed.

When wood waste burns, volatiles are distilled off below 500 F. Above 540 F exothermic reactions take place and the distillation of the volatiles continues with the evolution of about six per cent of the total available heat. Above 1100 F volatile gases are ignited. This is true providing the wood is not too wet, since evaporation of moisture absorbs about 1000 Btu per pound of the moisture present.

Basic Considerations

With the exception of combustion of elementary carbon, oxidation reactions occur in the gas phase. The combustion mechanism is that of rapid chain reactions which are complicated, but the process of burning is controlled more by external factors such as concentrations, temperature and the manner of mixing of the primary and secondary air supply than by the difference of composition and other characteristics of the fuel.

At the temperature of combustion, hydrocarbons rapidly dissociate into free hydrocarbon radicals which are liable to oxygen attack and are highly reactive.

Combustion depends on temperature, time and turbulence, often referred to as the "three T's." There must be sufficient time to ignite and burn the fuel completely; the temperature must be high enough to ignite and burn it properly; and there must be sufficient turbulence in the furnace to insure thorough mixing of the gases. When these factors are in perfect relationship, there should be complete combustion and no smoke. On the other hand, when they are not in harmonious relationship, the resulting incomplete combustion will produce smoke, eye irritants such as aldehydes, alkylperoxites and other organic compounds, and particulate matter, such as fly ash and soot.

Burning of oily rags and material containing paints or lacquers is a matter of temperature. When the fire is hot enough, the rags may be introduced in small quantities and burned smokelessly. The temperature should be at least 1200 F.

Incinerators are designed for a given quantity of combustible and it is not well to use the incinerator until sufficient waste material has been accumulated to warrant its use. Should the quantity vary greatly, black, white or brown smoke is likely to result.

Generally speaking, black smoke indicates insufficient air, whereas white or brown smoke shows too much air.

Silo-Type Incinerator

In the single combustion chamber or "silo" type of incinerator, such as has been characteristic of the West Coast, there is little or no control of these factors. Although the single combustion chamber could be made to work satisfactorily under a system of careful feed and air control, it is usually not economical to do so in the small plants where feed is erratic and only superficial attention is paid to the burning operation.

Therefore, the Los Angeles County Air Pollution Control District will no longer grant new permits to build or use incinerators of this type, although rules of operating procedures have been devised to use such incinerators as were in existence prior to February 1948.

Multiple-Chamber Type

Since the silo-type incinerator is so difficult to control, designers have more recently turned to multiple-chamber incinerators which consist of a furnace, a mixing chamber and a combustion chamber. In this type proper temperatures are more easily maintained because the retaining and bridge walls become hot refractory surfaces which receive heat from the flame and transmit it to the cooler portions of the burning mixture, thus increasing the rates of ignition and combustion. Also, at proper temperatures, the unburned gases have a chance to burn when mixed with the proper quantity of air in the second chamber.

Provision must be made for the admission of air, in the correct quantity, to the primary combustion chamber in such a manner as to initiate and facilitate proper combustion; also into the second chamber to assure smokeless burning. Moreover, the velocity of the gases at the entrance to the second chamber must be sufficient to create a pressure that will insure introduction of secondary air and create the desired turbulence.

Primary and secondary air ports should have adjustable controls and sufficient draft must be provided by either natural or artificial means, to insure adequate quantities of air intake for all possible firing conditions.

While the required temperature will depend somewhat on the material being burned, the minimum gas temperature for both combustion chambers should be at least 1200 F. Auxiliary fuels, such as gas or oil, may be needed to provide more adequate control of temperature, although oil is undesirable as it adds another potential source of smoke.

Velocity of the gases in the secondary combustion chamber should be such as to allow sufficient time for the settling of particulate matter. Moreover, with a multiple-chamber incinerator the abrupt change in direction of the gases will assist greatly in settling out the particulate matter.

The authors offer the following observations among their conclusions:

Mechanical smoke indicators, by themselves, do not solve the problem of incomplete combustion. They serve only to act as a warning that smoke may be too dense. A smoke indicator is certainly of little value when the stack is in the open, for the emissions from the stack, should be visible to those responsible for its effective and efficient operation. When an electric eye is used, care must be taken to keep the instrument clean. An air jet will do this. Indicators are of some value where the heat is being utilized, however, and in that case they can save money.

There is an inclination on the part of the user to slough off the operation of his incinerator on an unskilled worker. But it is clear, as a result of existing legislation and present administration, that the task of incineration must be taken more seriously than has been the custom heretofore.

REVIEW OF NEW BOOKS

Any of the books here reviewed may be secured through Combustion Publishing Company, Inc., 200 Madison Ave., N. Y.

Boiler Feedwater Treatment Third Edition

By F. J. Matthews

British practice in treating feedwater is explained in this revision which is intended to give the small steam plant operator guidance in selecting proper treatment equipment.

The author first describes the various types of natural waters and their adaptability to use for boiler feed. He next deals with the principal operating troubles, giving the older corrective measures first and then showing how their failings have necessitated the development of modern improvements. Finally, there is a section on analysis, including the usual routine methods of testing required for the efficient operation of softeners.

Water-treatment practice in Great Britain closely parallels that in America, and it is interesting to note throughout the book the appearance of trade names familiar in this country. Also, a surprising preponderance of the numerous bibliographical references is to U. S. publications.

There are 208 pages in the book which sells for $4.50.

Air Pollution Control

By Stanley Scott and J. F. McCarty

This is one of a series of legislative reviews prepared for the State of California. It begins with a statement of the problem of air pollution and its causes. Then the review takes up experiences in various sections of California and analyzes some of the effects in terms of health, nuisances, economics and damages to crops and livestock. Methods of abatement are next taken up, including elimination at the source, dispersal of contaminants, and zoning controls. A major section of the review deals with the legal status of air pollution regulation on the state and local levels. In a selected reading list there are about fifty references to recent literature on air pollution.

For those desiring a concise review of air pollution problems this 38-page report to California legislators is well worth its cost of $1.

Heating Design and Practice

By Robert H. Emerick

In writing this book the author had two ends in view. The first was to present the basic theories of heating design with demonstrations of how these theories are worked out. The second was to bring together such allied subjects as the design of fuel handling and storage systems; the design of masonry chimneys and steel stacks; fireplaces, chimney pots and incinerators; the characteristics of industrial refractories and insulation; and the preparation of specifications and the analysis of bids.

These ends have been achieved, and the scope of the book has been extended, giving a curious mixture of power plant practice and the specific techniques of space heating. For small consulting engineering firms and for architects, the arrangement of the material in this form will likely prove advantageous. Its use as a text in colleges and as a reference for specialists in heating is another question because of the wide diversity of subject matter.

The author has done an especially creditable job in the chapters on designing steam, hot water and warm air heating systems. Illustrations of representative commercial equipment add to the value of the book.

The 454-page book sells for $8.

Generating Stations Fourth Edition

By A. H. Lovell

Although this book is subtitled "Economic Elements of Electrical Design," it gives a very comprehensive view of modern central station practice including corporate finance, station cost, typical load curves, plant location and station auxiliaries. Much emphasis is placed upon the interrelation of mechanical and electrical elements in the design so that there is an understanding of the possibilities and limitations of the two fields.

The chapter on station cost, based largely on articles which have appeared in *Electrical World*, brings together much useful information on comparative costs of steam, hydro and diesel plants. It also reviews recent developments in power plant design and considers the effects of interconnection on power systems.

Other sections of the book deal with economic conductor selection, bus systems, circuit breakers, protective relays and transmission lines.

There are 432 pages and the book sells for $6.50.

Modern Pyrometry

By Charles H. Campbell

Measurement of high temperatures is an important tool in research and develop-

ment. This book was developed from a lecture prepared for the Cleveland Chapter of the American Society for Metals and illustrates the relatively common as well as the new techniques in pyrometric practice and equipment. It includes photographs of many representative types of instruments.

The opening chapter deals with thermocouples and includes tables which show standard types and their limitations and types of protection tubes that may be used with thermocouples. The second chapter takes up temperature indicators, recorders and controllers, including electronic balancing mechanisms and methods of automatic temperature control. In the third chapter resistance thermometers, radiation pyrometers, photoelectric instruments and optical pyrometers are described. The concluding chapter is concerned with care and maintenance of pyrometers.

Containing 150 pages, the book sells for $4.

ALCOA—An American Enterprise

By Charles C. Carr

This book of 292 pages is a most interesting story covering the history and growth of one of America's largest companies—The Aluminum Company of America. Its inception was based upon the work of a twenty-two-year-old inventor, Charles Martin Hall, who, in 1886 at Oberlin, Ohio, discovered not aluminum which was already available at high cost, but a process that made possible its mass production through the electrolytic fission of aluminum oxide. This process was destined to make low-cost aluminum available for innumerable applications. With the aid of Alfred E. Hunt, a metallurgist, and a group of backers in Pittsburgh, the process was launched commercially in 1888 by the Pittsburgh Reduction Company.

Following an account of Alcoa's beginning and the men associated with the enterprise, the book reviews the early patent problems, the procurement of bauxite, the Company's early relations with the Government under the Sherman Act, and later actions under the anti-trust laws, its contribution to winning both World Wars, the intervening period, ending with present postwar competition.

The author was for many years the Company's director of public relations and therefore has both first-hand information and ready access to the essential records. Upon retirement he undertook the writing of this book.

Bound in cloth, the book is priced at $3.50.

Essentials in Problem Solving

By Zuce Kogan

This little book makes fascinating reading—not in the generally accepted sense of being easy to read, for it requires some study if one is to get the most out of it, but rather because it presents certain ideas in a new light. The title, of course,

does not refer to mathematical problems. The examples employed to illustrate the line of reasoning are well chosen and enliven what otherwise would be more or less abstract logic. Without attempting to review the text, it may be summed up by the statement that the essential to effective problem solving is the application of general principles.

Publication is by the author, Zuce Kogan, a consulting engineer, at 724 Sheridan Road, Chicago 13, Ill., and the price is $3.00.

More Emphasis on Basic Science Needed

A plea that all engineering schools should devote themselves to ways of making substantial improvements in their courses of study has been made by the Committee on Adequacy and Standards of Engineering Education of the Engineers' Council for Professional Development, as a result of an extensive study made by this committee. Chairman S. C. Hollister, Dean of Engineering, Cornell University, reporting for the committee, says: "It becomes clear that there is going to be a shortage of engineers for many years to come. At such a time, in the national interest, it is of paramount importance that the best possible education in engineering be provided by our schools. Each man is going to be called upon to cover a greater range than heretofore, if the engineering needs are to be met. Every school should devote itself to ways of substantial improvement of its program, to the end that its graduates will meet the responsibilities being placed upon them."

Obsolescence of Methods

Tracing the history of engineering education, the committee pointed out that emphasis on engineering arts rather than engineering science which is all too prevalent in the engineering colleges, results in rapid obsolescence of the methods and information learned whereas education predicated on science and the "engineering approach," will sustain the engineer for his lifetime. Because educators should be preparing students for professional work that will reach a maximum culmination twenty or more years hence, courses least likely to obsolesce should be given. In this category the committee placed mathematics as the outstanding example. However, all basic sciences if taught in a manner such that knowledge of them makes available working tools will be a sustaining part of the curriculum.

According to the committee the pressure upon engineering schools to provide general education in addition to an increased scientific and technical training brings them constantly face to face with the limitation in time imposed by the conventional curriculum. "Other professions have had to face this issue," stated the committee. "If engineering maintains professional stature, it will have to organize accordingly."

Cathodic Protection of Steel Pipe Underground

Underground corrosion of steel pipe has been estimated to cost 600 million dollars annually in the United States. Efforts to reduce this toll have been stimulated by defense requirements for steel and other metals. Workers in the field have learned that underground corrosion can be greatly reduced by cathodic protection techniques, in which the structure is maintained at a suitable negative electrical potential.

A recent study[1] by W. J. Schwerdtfeger and O. N. McDorman of the National Bureau of Standards corrosion laboratory provides a better understanding of the mechanism of this important method of inhibiting underground corrosion. The study centered around laboratory determination of the optimum potential to be maintained for effective protection. By eliminating uncertainties inherent in field measurements, it was possible to determine an optimum protective potential having a firm scientific basis. The value arrived at —minus 0.77 volt referred to a saturated calomel electrode—was confirmed by weight-loss measurements on electrodes maintained at the selected potential in five corrosive soils.

Normal corrosion of iron and steel underground is largely an electrolytic phenomenon. When iron is exposed to the soil, local differences in electrical potential develop at the surface of the metal, resulting in the formation of numerous small corrosion cells. This means that electric currents flow through the soil from certain areas (anodes) to areas of less negative potential (cathodes), with accompanying loss of metal from the anodes and evolution of hydrogen at the cathodes. When cathodic protection is applied, direct current from an external source is caused to flow through the soil from an auxiliary anode toward the corroding surface. This applied current causes the cathode potentials to approach the anode potentials, and thus reduces the corrosion currents.

The question of the potential at which an underground structure should be maintained in order to inhibit corrosion is of considerable interest. Insufficient potential will give inadequate protection. On the other hand, maintaining a greater potential than is needed is unnecessarily costly, since this requires supplying a larger external current through the resistive earth.

The current required to maintain a -0.77-volt protective potential is not uniform. With most of the soils tested the necessary current diminished to a fairly stable value after about 3 weeks.

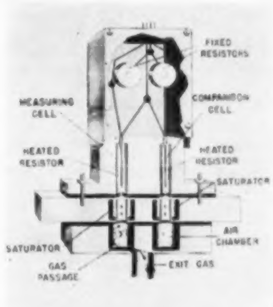
These uncertainties were eliminated in the NBS laboratory in arriving at the value of -0.77 volt referred to a saturated calomel electrode. Since this value corresponds approximately to -0.85 volt referred to the copper-copper sulfate electrode, the work confirms the practice of cathodic-protection engineers for the special condition when all IR drop is eliminated except that which is included in the field of the normal corrosion circuits.

[1] For further details of this work, see "Potential and Current Requirements for the Cathodic Protection of Steel in Soils," W. J. Schwerdtfeger and O. N. McDorman, *J. Research, NBS*, **47**, 104 (1951), RP 2233.

New Equipment

CO_2 Recorder

The Hays Corporation, Michigan City, Ind., has made available a new CO_2 recorder for use in large industrial power plants and central stations. The instrument utilizes the thermal conductivity principle of gas analysis and electronic-type operation. Gas to be analyzed flows through a gas passage from which a portion diffuses through a saturator into a measuring cell. As gas comes into the cell it conducts heat from the heated resistor



in proportion to the gas thermal conductivity, thus changing the electrical resistance. At the same time air diffuses from an air chamber into a comparison cell, where it conducts heat away from a heated resistor proportional to its thermal conductivity. The change of resistance in the comparison cell resistor is compared with that of the measuring cell resistor in the bridge circuit of the analyzer. The bridge circuit is connected so that the resulting measurement is amplified, indicated and recorded.

Self-Priming Pump

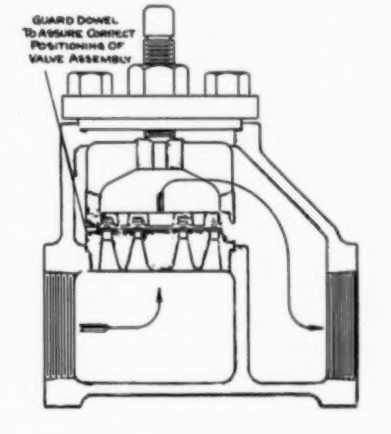
A new line of self-priming motor pumps has been introduced by Ingersoll-Rand Co. 11 Broadway, New York 4, N. Y. They are intended for applications under suction lift where it is impractical to use con-

ventional centrifugal pumps and may be used for mine drainage, bilge pumping, sump draining and irrigation service. The pump impeller discharges through two

passages, the upper one of which during priming discharges a mixture of vapor and liquid into the discharge chamber. Here the vapor separates from the liquid and passes out the discharge pipe, while the remaining liquid re-enters the impeller through the lower passage. When the suction pipe is finally filled with liquid and the pump is primed, flow through the lower passage reverses, and both passes act as normal pump discharges. The pumps are built in sizes from $^1/_4$ to 25 hp, with capacities up to 800 gpm and heads up to 180 ft.

Air Check Valve

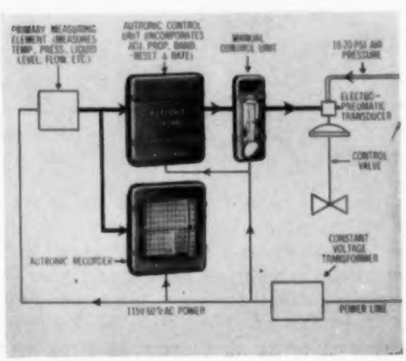
Pennsylvania Pump and Compressor Co., Easton, Pa., has developed an air check valve for installation on discharge lines of air and gas compressors. This valve dispenses with the customary arrangement of stop, safety and globe valves;



prevents leakage of pressure through the compressor during the off cycle; dampens pipe-line pulsations; and permits repairs without shutting down where more than one compressor is on the line. It also safeguards against damage due to failure to open a valve when starting a compressor.

Control System

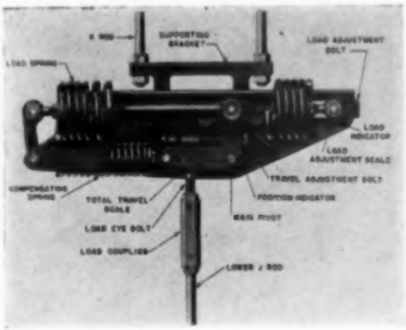
An automatic all-electronic instrumentation and control system for use in chemical and food processing plants, refineries, industrial power plants and central stations is announced by The Swartwout Co.,



18511 Euclid Ave., Cleveland 12, Ohio. The Autronic Control System, as it is known, consists of three basic units: primary sensing element, Autronic control unit and final control element. The primary sensing element generates a voltage directly proportional to any change in process variable. This voltage is transmitted to the Autronic control unit where it is continuously modulated by electronic means. The latter unit then transmits the resulting direct current to the final control element which may be electrically or pneumatically operated. A recorder and a manual controller may also be included in the system, which is suitable for controlling such variables as temperature, pressure, level and flow.

Constant-Support Hanger

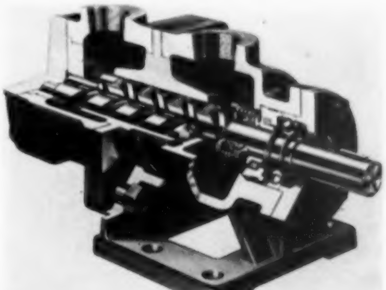
A new constant-support hanger, Model L, providing simplified field adjustment, increased travel range and greater load capacity with a smaller number of springs and fewer chassis sizes is now available



from Grinnell Co., Inc., 260 West Exchange St., Providence, R. I. Three refinements incorporated in this model are a structure designed for center support which places equal dimensions on each side of the center supporting line, non-resonance in the springing system and provision to give less horizontal shift of the load line as the load shifts from cold to hot positions.

Oil Pump

De Laval Steam Turbine Co., Trenton 2, N. J., has announced a new IMO pump designated as A313B and designed to handle oil at pressures up to 275 psig with intermittent pressures as high as 325 psig. This positive-displacement pump can be used for capacities to 80 gpm in pumping light or viscous fluids in hydraulic systems, for fuel oil burners, and for lubrication and governing systems.



New Catalogs and Bulletins

Any of these may be secured by writing Combustion Publishing Company, 200 Madison Avenue, New York, 16, N. Y.

Condenser Tubing

A new and expanded 44-page edition of "Anaconda Tubes and Plates for Condensers and Heat Exchangers" has been made available by The American Brass Co. It discusses the application and installation of condenser and heat exchanger tubes; also plates for tube sheets, heads and baffles. Two new subjects introduced in this edition are "Operational Factors Affecting Tube Life" and "Corrosion Factors in Condenser Tube Service."

Controlled-Volume Pumps

In a 24-page illustrated Bulletin, No. 251, issued by the Milton Roy Co., motor-driven controlled-volume pumps are described. These are precision pumps designed to meter practically any liquid in measured volume and serve as important parts of chemical feed systems. Details on regulation of pump capacity by plunger speed and stroke adjustments are included along with capacity-pressure selection tables.

Fusion Welding of Nickel

Technical Bulletin T-2 is a 44-page booklet on the fusion welding of nickel and high nickel alloys published by The International Nickel Co., Inc. Illustrated by more than 30 tables and about 50 drawings and photographs, it covers various forms of gas and electric arc welding. Among the topics discussed are pickling, testing and inspection, safety methods, shrinkage of welds, etching and overlays.

Gas Scrubber

Peabody Engineering Corp. has issued a six-page bulletin, 203-B, which includes a capacity curve sheet, cross-section diagram and typical installation pictures of gas scrubbers for the recovery of product, the purification of gases and the elimination of atmospheric pollution.

Ion-Exchange Materials

National Aluminate Corp. has prepared a 28-page bulletin, No. 58, on Nalcite HCR, a styrene-type cation exchanger. Physical and chemical properties are discussed along with applications for industrial softening and municipal softening. Sufficient data are included to make the bulletin useful in planning and designing ion-exchange-type water-treating installations.